Historic, archived document

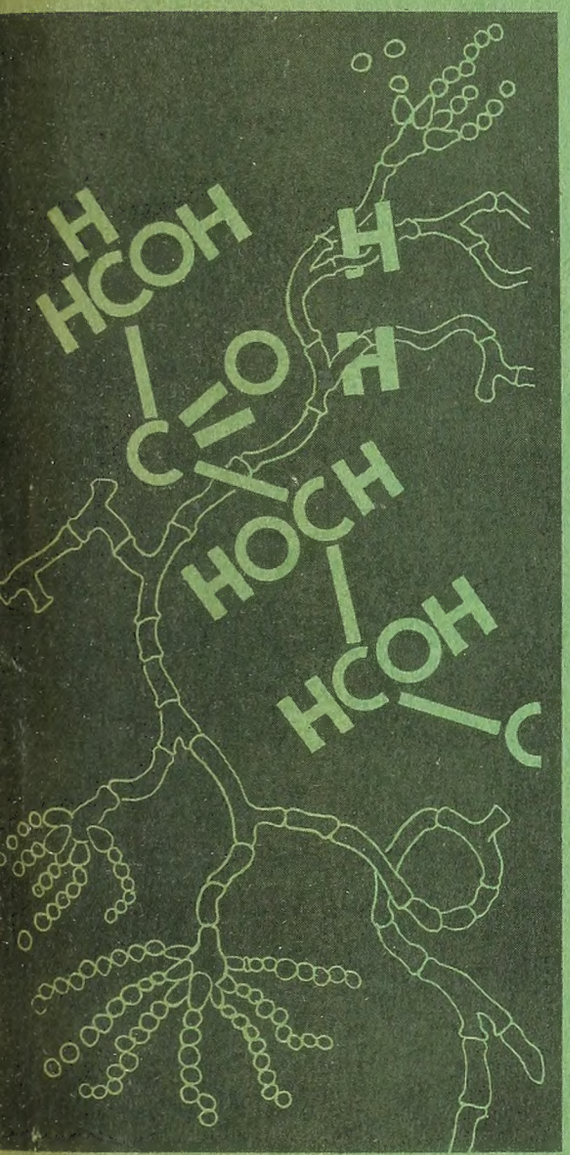
Do not assume content reflects current scientific knowledge, policies, or practices.

A381
R31Ac
Cop. 3

ARS - 71 - 13
May 1959

LIBRARY
CURRENT OFFICIAL RECORD
JUN 11 1959
U. S. DEPARTMENT OF AGRICULTURE

TYPE REACTIONS in fermentation chemistry



Agricultural Research Service

U. S. DEPARTMENT OF AGRICULTURE

TYPE REACTIONS IN FERMENTATION CHEMISTRY

Lowell L. Wallen, Frank H. Stodola, and

Richard W. Jackson

This publication was prepared by the

Fermentation Laboratory

Northern Utilization Research and Development Division

Peoria, Illinois

ARS-71-13 May 1959

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

The last quarter century has witnessed tremendous interest in the field of microbiological chemistry. One main line of inquiry has dealt with the so-called "type" reactions, such as oxidation, reduction and hydrolysis effected by microorganisms. In the course of our work in the Fermentation Laboratory we have made use of these reactions in the development of processes to utilize surplus agricultural products. In recent years we have found it increasingly difficult to keep abreast of new developments due to the large number of papers on the subject scattered throughout the chemical and biological literature.

Consequently, a systematic survey of the literature on type reactions was begun three years ago and this monograph is the result. We have limited the number of type reactions to fourteen. To make our material more manageable, we have included only those reactions consummated by whole cultures, washed-cell suspensions, mycelial mats, or dried whole cells. The large number of reactions catalyzed by cell-free enzyme preparations were thereby excluded, but these are well covered by frequent reviews in the field of enzymology.

Another decision was to cite only the first report in the literature of a particular type reaction involving a given compound and microorganism. We usually excluded reports that did not describe the separation of a chemical entity. Structural formulas have been employed to show clearly the molecular changes which occur during the reaction. Entries have been arranged primarily according to increasing molecular weight, but, when a compound appeared more than once, chronological priority was employed. Indices to reaction types, microorganisms and authors are provided to make the data more available. Currently accepted nomenclature has been given preference in designating microorganisms. Any nonvalid name found in the literature is parenthesized immediately following or below the valid Latin name.

One object of this book is to demonstrate to the organic chemist the potential usefulness of microorganisms for carrying out certain reactions that are difficult or impossible to bring about by orthodox chemical means. One must remember, however, that these simple living forms are complex dynamic systems, requiring careful control of nutrients, aeration, temperature and pH if the fermentation is to proceed along the desired path. To aid the less experienced, we have presented brief discussions and references to the literature dealing with fermentation equipment and procedure. A short history of the development of microbiological type reactions is given to show early work in the field, present status and future prospects.

The Authors

Peoria, Illinois
December 1958

CONTENTS

Preface.....iii

Introduction..... 1

Tools and Methods of Fermentology..... 3

Source and Maintenance of Microorganisms..... 3
Equipment and Materials..... 5
Basic Procedure and Variables..... 7
Operation of Type Reactions..... 10
Literature Cited..... 12

General References..... 13

Type Reactions..... 15

I. Oxidation..... 15

II. Reduction.....227

III. Decarboxylation.....320

IV. Deamination.....347

V. Glycosylation.....374

VI. Hydrolysis.....391

VII. Methylation.....408

VIII. Esterification.....417

IX. Dehydration.....424

X. Asymmetric Dismutation.....430

XI. Condensation.....435

XII. Amination.....439

XIII. Acetylation.....441

XIV. Amidation.....443

Type Reaction Index.....445

Microorganism Index.....451

Author Index.....471

TYPE REACTIONS IN FERMENTATION CHEMISTRY

INTRODUCTION

In the development of modern science and technology, the contributions of the organic chemist have been indispensable. His primary function has been to produce a wide variety of carbon compounds for many uses, and to aid in the development of experimental methods and theories. A great majority of these compounds have been synthesized by the organic chemist in the laboratory, employing methods he has devised. A considerable number have been isolated from natural sources, while many others have been prepared via the so-called microbiological type reactions. The development of these three methods of obtaining organic compounds is presented in the following brief historical review.

With synthesis such an integral part of modern organic chemistry it is hard to realize that this technique had no place in the early development of the subject. Actually all the groundwork on which the science is based was done on natural products or compounds derived from them. Not until 1828, when Wöhler accidentally prepared urea from ammonium cyanate, was it realized that synthesis was within the power of the chemist. The systematic employment of this powerful tool, however, had to await the development of structural organic chemistry, and another 17 years passed before a second example of synthesis was forthcoming—the preparation of acetic acid by Kolbe in 1845. Aided by the great clarifying principles laid down by Kekulé and Couper during the next decade, organic chemistry underwent a tremendous expansion both in theory and practice. The magnitude of this growth is reflected in the increase over the years in the number of known organic compounds. Prior to 1837 only about a thousand organic compounds had been characterized; by the time the first edition of Beilstein's Handbuch appeared in 1882, this number had grown to 15,000. Organic chemistry was then entering its golden age of synthesis, which was to add another 60,000 compounds by the turn of the century. Most of the effort during this time was directed toward the synthesis of dyes and drugs, and an important byproduct was the elaboration of many new experimental methods and theories. That little attention was devoted to the chemistry of living systems is understandable, for most organic chemists of the era were appalled by the difficulties attending the study of natural processes. Fortunately this period produced Emil Fischer, who believed that all physiological changes were chemically comprehensible and that the first step toward comprehension was the elucidation of the structures of the organic compounds involved in these changes. With rare success, Fischer proceeded to clarify the chemistry of the carbohydrates, the proteins, the purines, and the tannins, thereby laying a secure foundation for the emerging science of biochemistry. This branch of learning was destined to enhance the whole approach to biology by emphasizing its investigation at the molecular level.

About this same time the wonders of the microbial world were being revealed by Pasteur. More and more new forms were being discovered and their physiology investigated. As early as 1864 Pasteur was able to explain the production of vinegar as an oxidation of ethyl alcohol to acetic acid by "Mycoderma aceti". By 1880 Boutroux had oxidized glucose with this same organism and identified the product as gluconic acid. In 1886 Adrian Brown reported the use of "Bacterium aceti" for oxidizing mannitol to fructose, and n-propyl alcohol to propionic acid. Ten years later Bertrand established that the oxidation of sorbitol by Acetobacter xylinum produced sorbose. These observations led to the conviction that the assimilation of organic compounds in microorganisms was a stepwise process susceptible to elucidation. It was becoming apparent that these lowly forms, because of their simplicity and ease of manipulation, were often superior to plants and animals for the study of life processes.

The concept of the stepwise nature of microbial reactions received additional confirmation through the later work of Bertrand, who by 1904 had oxidized six polyhydric alcohols to the corresponding ketoses by means of A. xylinum. About this time Schardinger in Germany demonstrated that bacterial hydrolysis could also proceed in orderly steps to permit the isolation of crystalline cyclic dextrins by the partial hydrolysis of polysaccharides. An event of great importance soon followed, namely, the isolation of hexose diphosphate as a yeast product by Harden and Young, which was to initiate intense activity in the field of intermediary metabolism of microorganisms and to have a profound influence on our knowledge of the chemistry of higher forms of life. In 1911 another type of microbial transformation was disclosed by Lintner and von Liebig, who demonstrated the conversion of furfuraldehyde to the corresponding alcohol by yeast. Many other examples of yeast reductions were provided by Neuberg starting in 1913 and continuing during the next quarter century.

With all this work came the realization that the chemist now had available a new and elegant way of obtaining organic compounds, which would supplement his existing methods. The new procedure resembled isolation from nature in that living systems, the microorganisms, were involved, but it also had something of the character of organic synthesis in that the compounds were produced by stepwise reactions from purified reactants under carefully controlled conditions—much as in the chemist's flasks. In many cases the microbiological method showed distinct advantage over chemical synthesis in that the microbial reactions were highly specific as to point of attack on the molecule and gave high yields of easily isolable material. Moreover, the product would be optically active when a new asymetric center was produced.

Interest in the microbiological type reactions was greatly increased when it was shown about 1934 that the l-sorbose needed for the ascorbic acid synthesis could be prepared on a large scale by the oxidation of

sorbitol by Acetobacter suboxydans. The commercial success of this process did much to attract attention to the possibilities inherent in fermentation reactions, and many new types were discovered. The more recent microbiological oxidation of steroids at specific positions in the molecule has added greatly to the accomplishments in the field and has pointed up the discoveries and applications that remain for the future.

TOOLS AND METHODS OF FERMENTOLOGY

Source and Maintenance of Microorganisms

The most important single item in a microbial process is the microorganism whose enzymes are responsible for converting the substrate to a product. It is practically always necessary to use pure cultures. Although all pure cultures were obtained originally—and often can be re-isolated—from natural fermentations, soil, diseased tissue, and decomposing material, it became desirable to keep pure cultures and maintain them indefinitely. As the applications of microbiology have multiplied, culture collections have increased in number and in size. They are the best sources of the microorganisms one may need, because culture collection organizations are staffed with experts who pay a great deal of attention to purity, identification, and vigor of growth. Such collections are found in many parts of the world; some contain several thousand cultures of diversified types. The names and locations of some of the largest and best known collections are given here. All publish catalogs except number 2.

1. American Type Culture Collection (ATCC), Washington, D. C.
2. ARS Culture Collection, Northern Utilization Research and Development Division (NRRL), Agricultural Research Service, U. S. Department of Agriculture, Peoria, Illinois.
3. Centraalbureau voor Schimmelcultures. Molds and actinomycetes are kept at Baarn, Holland; yeasts, at Delft, Holland.
4. Centre de Collections de Types Microbiens (CCTM), Lausanne, Switzerland.
5. National Collection of Industrial Bacteria (NCIB), Teddington, England.
6. Commonwealth Mycological Institute, Kew, England.
7. Pringsheim Culture Collection of Algae and Protozoa, University of Cambridge, England.
8. Culture Collection of Algae at Indiana University, Bloomington, Indiana.
9. National Collection of Type Cultures (NCTC), London, England.

The Centre de Collections de Types Microbiens, although maintaining a collection, serves primarily as a clearing house for information on the location of cultures. Most collections cooperate, and CCTM publishes lists of available strains. When a request is received by CCTM, it is forwarded to the appropriate collection which in turn mails the culture to the person requesting it.

Every organism has its own pattern of nutritional and environmental requirements. The medium must contain carbon and nitrogen sources as well as minerals in the proportions to support good growth. Vitamins may also be required. Carbon and nitrogen are often provided in the form of protein hydrolysates or meat extracts. Yeast extract or liver extract may fulfill vitamin requirements. Frequently, minerals are supplied by the addition of inorganic salts, although the trace amounts present in tap water may be sufficient for many microorganisms. When carbohydrate is needed to furnish extra carbon and energy, glucose or sucrose is most commonly used. The components of the medium are dissolved in water and the solution is diluted to the required volume. Liquid medium used for growing inoculum is distributed into test tubes or flasks, which are then closed with cotton plugs and sterilized at 120° C. (15 psi) in an autoclave for 10-15 minutes (10).

If a solid medium is desired, agar is incorporated in the medium prior to sterilization. When an organism is to be grown aerobically, a slanted surface is prepared by allowing the agar medium to solidify while the tube containing it is inclined at an angle of approximately 25-30° to the horizontal. The slanted surface of the medium is inoculated by spreading living cells of the microorganism, contained in a sterilized wire loop, over the surface. If an anaerobic organism is to be cultured in a solid medium, the agar is allowed to solidify with the tube in an upright position. The agar medium is then inoculated by stabbing the surface of the medium with a sterilized wire loop containing cells of the desired microorganism. Anaerobes are also commonly grown in liquid media.

Inoculated tubes of agar or liquid medium are incubated at the temperature best suited for optimum cell development; this is generally 25-30° C., although some bacteria require 45° C. After cultures have developed on agar satisfactorily, they may be stored in a refrigerator. Some bacteria can also be stored in the refrigerator in the liquid medium in which they were grown. A spore-forming bacterium can be stored indefinitely by pouring a suspension of sporulated cells on sterile soil and drying the resultant mud at 45° C. under reduced pressure. Soil cultures of streptomycetes and molds are prepared in a similar fashion, except that the culture broth of cells is incubated only two days before being added to the sterile soil; drying is done at room temperature.

A widely used procedure whereby many bacteria, yeasts, and molds may be prepared for storage over long periods of time is that of lyophilization (8). In this process the microbial cells are suspended in a small volume of sterile fluid such as bovine serum, skim milk, peptone solution, or lactose solution. The suspension is placed in a small glass tube closed at one end, and then subjected to high vacuum while in a frozen state. The cells after drying are sealed in the tube while under vacuum, and thus remain viable for many years. Another less used procedure for maintaining cells in a viable condition is that of covering them with a 1 cm. layer of sterile mineral oil. This procedure has given good results when used for the preservation of yeasts.

Different strains of the same genus and species vary in their capacity to carry out a biochemical transformation. They are called natural variants. Genetic constitution can sometimes be altered through X-ray or ultra-violet irradiation, and microorganisms can thereby be induced to demonstrate novel or new synthetic powers not previously manifested. Compounds such as colchicine and the mustard gases are also mutagenic agents. The changed forms are called mutants. There are still other genetic approaches, e.g., the hybridization of yeasts.

As already emphasized, the purity of a culture is important. Contamination must be avoided. Cotton plugs are poisoned to keep out mites and mold growth. Precautions should be exercised when transferring spores of a "dusty" nature to prevent setting up contaminating aerosols. Constant attention to such details and a high standard of laboratory cleanliness will help to insure that fermentation work is not ruined by contamination.

Equipment and Materials

Practically all fermentations are conducted in a liquid aqueous medium. The simplest container ordinarily employed is a flask protected from contamination by a cotton plug. The flask is generally of the Erlenmeyer type and may vary in size from 100 ml. to the 2800-ml. capacity of the Fernbach flask. If a closed system with multiple ports is needed, a flask with side necks or a bottle with a large neck to accommodate a stopper with connecting tubes serves well. If agitation of the flasks is desired, it is accomplished by incubating them on a shaking machine. Two types of shakers are acceptable. One is reciprocating while the other moves the platform on an eccentric in a horizontal plane. Grain sieve machines of the second type may be converted for heavy duty use in fermentation work. Shakers with tilting platforms are not satisfactory because the amount of shaking is a function of the distance of the flask from the center of the platform.

Deep fermentors for laboratory experimentation may range from large flasks or bottles, as already mentioned, to stainless steel tanks of 10 to 50 liters (6). Cylindrical stainless steel containers fitted with stainless steel tops are widely used. The top, which mounts various equipment, rests on a gasket and the fastening clamps are attached around the bottom of the jar. The tanks and jars are provided with necessary ports for inoculation, aeration, sampling, and addition of antifoam or nutrient material. The closed tanks may be jacketed for temperature control while the cylinder type is immersed in a water bath to control temperature. Antifoam material is nearly always added to the tank-type fermentation; this can be done automatically by means of electrodes which, when shorted by foam, actuate a solenoid valve. Air is sterilized by filtration, as in commercial operation, and then humidified before being conducted to the fermentor chamber. The air is introduced through a perforated pipe or through a porous ceramic cylinder or candle. For flasks and bottles, the porous ceramic may be in the form of a small ball attached to a glass tube. Experimental tank fermentors are generally equipped with stirrers so that the absorption of oxygen from the air may be more efficient. Deep tank fermentors may range in size up to 50, 100, or even many thousands of gallons.

Many different kinds of deep fermentors have been used. The Waldhof fermentor is used both here and abroad to grow yeast cells. It has a powerful motor to stir the contents of an open tank and entrain the air which is introduced at the bottom. This system may be modified so that the liquor at the top with foam and air are made to travel to a central vortex from which they are pumped to the bottom of the tank and thence upward through the fermentation liquor. The Humfeld fermentor is a small laboratory apparatus following these principles. When oxygen is not needed or is excluded in the fermentation, the sparging device and stirring mechanism are omitted and less head room needs to be reserved in the fermentor.

A great variety of media is used in the fermentative application of many hundreds of different kinds of microorganisms. A simple medium may contain glucose, urea, and magnesium and phosphate ions. The organism, however, may require amino acids, pyrimidines, and vitamins. Despite the fact that the physiological requirements of many organisms have been studied in detail and that good progress has been made in developing successful "synthetic" substrates, most media used today are empirical. The cheaper materials, of course, must be used in commercial fermentations. The sugar may be crude corn, beet, or cane molasses. The required complex nitrogen compounds may be furnished as hydrolyzed crude protein, soybean meal, corn steep liquor, or distillers' solubles.

Practically all fermentations aerated with a stream of air present a foaming problem. As mentioned, the foam may be handled mechanically by pumping it to the bottom of the fermentor and thence up through the liquor. Chemicals may be used but can be objectionable in the preparation of food materials. In such instances, the problem can be solved without addition of chemicals by leaving excessive headroom in the fermentor, but production is curtailed because the effective capacity of the fermentor is reduced. Octadecanol and heptadecanol are effective chemicals and are "clean" substances with which to work. More recently the silicone antifoam agents have been developed and are extensively used. Cheaper materials are generally used in commercial fermentations; examples are mineral, corn, lard, and soybean oils. Antifoam agents can exert toxic action on a fermentation and one must be on guard against this. On the other hand, the oils of antifoam preparations have been found to be metabolized in some fermentations and to increase the yield.

Development of equipment for pH control (4,7) of fermentations has been slow. The reason is that the glass electrode so universally employed did not withstand repeated heat sterilization. It has now been improved in this respect. Another solution of the problem has come through the use of ethylene oxide as a sterilizing agent (9). With a satisfactory sterilizable electrode available, one can buy or set up apparatus to record and control pH.

Basic Procedure and Variables

The medium and all apparatus that is patent to the fermentation system are ordinarily sterilized with steam at 15 psi (121° C.) for 15 minutes. More drastic conditions are sometimes called for. Also, it may be more convenient to sterilize a substance like $CaCO_3$ separately in dry condition. Occasionally, it is better to steam-sterilize a reducing sugar, e.g., glucose, separately because the sugar reacts unfavorably with some other nutrient. As stated, ethylene oxide has gained favor as an alternative to steam. Sterilization of liquids containing labile material can be accomplished by filtration through filters having very fine pores.

The inoculation of the sterilized medium is generally done with a culture of vigorously growing cells amounting to 5 or 10 per cent of the total volume. The amount of inoculum and the manner of preparation are often quite important. If a lyophilized culture is used, a tube may be opened and the organism grown on an agar slant. Several loops of growth are then transferred to a liquid medium which, after one, two, or three stages of transfer and expansion, is used to inoculate the fermentation tank. Many of the

fungi produce spores in great numbers; these may be harvested and germinated to start a fermentation. The medium used for germinating spores or otherwise producing inoculum often differs to some degree from the fermentation medium.

If a limited amount of oxygen is sufficient, the fermentation may be conducted in an unshaken flask, i.e., in still culture. If more oxygen is needed, the flask is shaken. In larger equipment, the introduction of air entails agitation of the liquor. Anaerobic fermentation, as exemplified in the production of acetone and butanol, is conducted with strict exclusion of air. In ethyl alcohol production, sufficient yeast cells may be obtained under aerobic conditions with supply of some air; then the air is cut off and ethyl alcohol is produced by an anaerobic process. Some microorganisms, particularly the molds, do best if allowed to grow and metabolize at the surface. Though oxygen may play an important role in the fermentation, it is a kind of still culture. Agitation wets the mycelial growth and causes it to be submerged, sometimes to the detriment of the fermentation. Submerged fermentation is the most economic because much larger volumes can be fermented at a lower cost. Generally it is possible to find strains of any given organism that ferment when submerged. If such strains are not available, then it is useful to expand the scale of surface culture by replacing flasks with trays, several of which can be accommodated in an incubator.

The rate of aeration is important in aerobic fermentations. Strictly speaking, air or oxygen is a nutrient and should be listed with carbohydrate, nitrogen source, and minerals, but is generally treated separately because of its different physical state. At any rate, to produce large numbers of cells of an organism it is necessary to supply all the basic nutrients—carbohydrate, nitrogen, phosphate, oxygen—in large amounts. Again, it is necessary to supply large amounts of oxygen, for example, in the rapid conversion of glucose to gluconic acid. It is therefore important to measure oxygen absorption rate. This measurement is ordinarily made by using a sulfite solution in place of the fermentation medium with all other conditions the same (3). Oxygen absorption rate (OAR) is expressed as millimoles of oxygen absorbed per liter of the solution per minute. Determined under several different conditions, it was found to be:

Container	Content, ml.	Condition	RPM	OAR
Flask, 1000 ml.	100	Rotating	200	0.25
Flask, 1000 ml.	100	Reciprocating	88	0.49
Flask, 2.8 l. Fernbach	300	Rotating	200	0.2
Flask, 2.8 l. indented Fernbach	300	Rotating	200	3.5
Flask, 2.8 l. indented Fernbach	25	Rotating	292	5.2
Fermentor, 20 l. with sparger and baffles		Air flow of 2 vols./vol. of medium/min. and agitation	550	7.2

Temperature control is generally necessary. It is accomplished by incubating flasks in a room held at a given temperature, by immersing a fermentor in a water bath, or by circulating a mixture of hot and cold water through the jacket of a jacketed fermentor. Fermentations are conducted at 25-40° C., very often at 25-30° C.

The control of pH is also important. For example, the production of citric and itaconic acid with molds goes best at a relatively low pH. Hydrochloric or sulfuric acid may be used to set the initial pH; a better way is to add some of the citric or itaconic acid itself. The conversion of glucose to gluconic acid proceeds best at neutrality or pH 6.5, and alkali must be continually added. The repeated sampling of, or addition to, flasks greatly increases the danger of contamination; in addition, it is difficult to keep track of the volume. If one is making a calcium salt, e.g., calcium gluconate, the problem is solved by adding an excess of $CaCO_3$ at the start of the fermentation. The acid being formed is automatically neutralized. In many instances, it is better to go to a 20-liter fermentor equipped with an automatic titration device, whereby the pH is held constant and at the same time the system is kept closed and sterile. In large fermentors, the liquor can be circulated from the main fermentor to a small chamber containing the electrodes.

The time of fermentation may vary widely—from 20 hours for conversion of a 15 per cent solution of glucose to gluconic acid—to 6 or 8 days for transformation of a 10 per cent sugar solution to itaconic acid. The more rapid is the fermentation, the faster the turnover of material in the plant, and the greater the efficiency.

Not all substrates that one wishes to subject to fermentation are water-soluble. An example is progesterone. To obtain a better contact between it and the modifying organism, one may dissolve it in a little alcohol or acetone and then pour the solution into the aqueous medium. A fine dispersion results. Again, even though an ingredient or a particular substrate is soluble in the medium, better results are sometimes obtained by introducing the particular item gradually.

Continuous fermentation has been much discussed and tried (1). Success has been only mediocre. The difficulty is contamination. In discontinuous fermentations, contamination is limited to one batch and may not have time, after getting started, to do real damage. A continuous fermentation must be restricted to the pure culture without any invader, week after week. This can be accomplished with a vigorous grower like Candida (Torulopsis) utilis. Here it is possible to feed the sugar solution in at the top of the fermentor and to draw off yeast cells continuously at the bottom or vice versa.

Operation of Type Reactions

In the use of microbiological procedures to produce a desired compound, it is important to employ care in the production of inoculum. The first step is the aseptic transfer of the selected organism whether from a culture on agar, a lyophilized preparation, or a concentration of spores, to an aqueous medium containing the nutrients necessary for abundant proliferation of the cells (5). However, should it be necessary, the organism can sometimes be adapted to an abnormal substrate such as nitrobenzene or chloronaphthalene by successive transfers to media containing some of the foreign compound in addition to required nutrients. Most fermentation reactions are accomplished without culture adaptation, so the cells can be grown on the medium most suitable for their optimal production. When the multiplication has progressed to the desired stage, usually within 24 hours, the cells can be used in an actively growing state in one or another production medium, or they may be used under the limited conditions of the washed cell technique. In the latter case, they are removed from the growth medium by centrifugation or filtration. The cells or mycelium are then re-suspended in a buffered medium after they are first washed with distilled water or buffer solution to remove residual ingredients of the growth medium. Other cell preparations have been used in place of washed cell suspensions, for example, cells dried in vacuo in the frozen state or at room temperature or in open dishes at room temperature, and cells dried through acetone treatment.

After a satisfactory cell growth or preparation is obtained, the compound which is to be tried as a substrate is introduced. A soluble compound is simply added in sterile aqueous solution, whereas a water-insoluble substance must be incorporated in the medium as particles of the smallest possible size in order to make available a maximum surface area exposed to the microorganism or its enzymes. Fine division of a water-insoluble compound is often accomplished by gradual introduction of the sterilized solution, in a water-miscible organic solvent, into the well-stirred and sterilized aqueous medium. Care must be exercised in choosing an organic solvent and the amount of solvent that will not be inhibitory to the metabolism of the microorganism or to the action of the enzyme in cell preparations. Some solvents used for this purpose are ethanol, propanol, acetone, and dioxane.

The time required for transformation of the substrate to product varies. Some reactions are complete within 24 to 48 hours, whereas others need to be continued for several weeks. Control of the medium, pH, temperature, aeration, and agitation may accelerate the conversion and thus reduce the total reaction time. Rate of transformation of substrate may be ascertained by conducting

appropriate tests upon small samples of the culture liquor withdrawn under aseptic conditions. The reaction rate may be expressed as the rate of disappearance of substrate or the rate of formation of product. When glucose is the substrate, the quantitative reduction of copper may be used to determine glucose concentration (11). If the product being formed from glucose is one like gluconic acid, which does not itself reduce copper, then the same method can be used without correction to determine the glucose concentration throughout the fermentation. Paper chromatography is useful as a qualitative procedure for the examination of culture liquors and can also be adapted to quantitative use.

The pH of the medium should be followed during the course of the fermentation. If the reaction product is an acid, titration of the culture liquor with alkali can serve as a measure of the amount of product present. Unexpected change in pH may indicate that a contaminating organism is present. One should employ microscopic examination to guard against contamination. For this purpose, a small quantity of culture liquor is withdrawn from the contents of the flask by means of a sterile pipet and examined at a high magnification.

When a microbiological reaction has reached completion, the product may be present in the culture liquor as a soluble compound, in an insoluble precipitate, gum, or oil, or in the mold mycelium or bacterial cells. If the product is in solution, particulate matter such as bacterial cells or mycelium may be removed by filtration or centrifugation. If proteins are present that interfere with extraction, evaporation, or other manipulation of the fermentation liquor, they may be precipitated with trichloroacetic acid. When the product is in the cellular material, it must be freed by crushing, grinding, ultrasonic treatment, or lysing of the cells (2, pp. 56-62). Should the reaction product be an insoluble precipitate, it can be separated by decantation of the culture liquor and cells. The product can then be suspended in water, filtered, and washed until free of residual impurities. If the product is contained in a mycelium, or is present as an insoluble oil, extraction may be a valuable step. Often a combination of procedures may prove effective. Loss of vulnerable products due to air oxidation, excessive temperature, or racemization must be minimized.

Literature Cited

(1) Beesch, S. C., and Shull, G. M.
1955. FERMENTATIONS. Ind. Eng. Chem. 47: 1857-75; ibid. 48: 1585-1603 (1956).

(2) Colowick, S. P., and Kaplan, N. O.
1955. METHODS IN ENZYMOLOGY. Vol. I. 835 pp. New York.

(3) Corman, J., Tsuchiya, H. M., Koepsell, H. J. and others.
1957. OXYGEN ABSORPTION RATES IN LABORATORY AND PILOT PLANT EQUIPMENT. Appl. Microbiol. 5: 314-18.

(4) Deindorfer, F. H., and Wilker, B. L.
1957. pH CONTROL IN SUBMERGED PURE CULTURE FERMENTATIONS. Ind. Eng. Chem. 49: 1223-6.

(5) Demain, A. L.
1958. MINIMAL MEDIA FOR QUANTITATIVE STUDIES WITH Bacillus subtilis. J. Bacteriol. 75: 517-22.

(6) Dworschack, R. G., Lagoda, A. A., and Jackson, R. W.
1954. FERMENTOR FOR SMALL-SCALE SUBMERGED FERMENTATIONS. Appl. Microbiol. 2: 190-7.

(7) _____ Lagoda, A. A., and Jackson, R. W.
1956. THE CONTROL AND RECORDING OF PH IN SMALL SCALE FERMENTATIONS. In Proceedings of the Instrument Society of America. New York. Paper No. 56-17-1: 1-8.

(8) Haynes, W. C., Wickerham, L. J., and Hesseltine, C. W.
1955. MAINTENANCE OF CULTURES OF INDUSTRIALLY IMPORTANT MICROORGANISMS. Appl. Microbiol. 3: 361-8.

(9) Judge, L. F., Jr., and Pelczar, M. J., Jr.
1955. THE STERILIZATION OF CARBOHYDRATES WITH LIQUID ETHYLENE OXIDE FOR MICROBIOLOGICAL FERMENTATION TESTS. Appl. Microbiol. 3: 292-5.

(10) Society of American Bacteriologists
1957. MANUAL OF MICROBIOLOGICAL METHODS. H. J. Conn, Editor. 315 pp. New York, Toronto, etc.

(11) Somogyi, M.
1952. NOTES ON SUGAR DETERMINATION. J. Biol. Chem. 195: 19-23.

GENERAL REFERENCES

Arnaudi, C.
1951. MICROBIAL OXIDATION OF STEROIDS.
Experientia 7: 81-9.

Barker, H. A.
1956. BACTERIAL FERMENTATIONS. 95 pp. New York and London.

Beesch, S. C., and Tanner, F. W., Jr.
1958. FERMENTATION. Ind. Eng. Chem. 50: 1341-54.

Bernhauer, K.
1932. DIE OXYDATIVEN GÄRUNGEN. 196 pp. Berlin.

Breed, R. S., Murray, E. G.D., and Smith, N. R.
1957. BERGEY'S MANUAL OF DETERMINATIVE BACTERIOLOGY.
ed. 7, 1094 pp. Baltimore.

Challenger, F.
1951. BIOLOGICAL METHYLATION.
Advances in Enzymol. 12: 429-91.

Delwiche, C. C.
1956. BIOLOGICAL TRANSFORMATIONS OF NITROGEN COMPOUNDS.
Ind. Eng. Chem. 48: 1421-7.

Eppstein, S. H., Meister, P. D., Murray, H. C., and Peterson, D. H.
1956. MICROBIOLOGICAL TRANSFORMATIONS OF STEROIDS AND THEIR APPLICATIONS IN THE SYNTHESIS OF HORMONES.
Vitamins and Hormones 14: 359-432.

Evans, T. H., and Hibbert, H.
1946. BACTERIAL POLYSACCHARIDES. Adv. in Carbohyd. Chem. 2: 203-33. See also, Scientific Report Series No. 6 of the Sugar Research Foundation, New York, 1947.

Fischer, F. G.
1948. THE USE OF BIOCHEMICAL OXIDATIONS AND REDUCTIONS FOR PREPARATIVE PURPOSES. pp. 159-196. In NEWER METHODS OF PREPARATIVE ORGANIC CHEMISTRY. 657 pp. New York and London.

Gale, E. F.
1951. CHEMICAL ACTIVITIES OF BACTERIA.
213 pp. New York and London.

Happold, F. C.
1950. THE OXIDATION OF AROMATIC RINGS BY MICROORGANISMS IN METABOLISM. Biochem. Soc. Symposia 5: 85-96.

Karow, E. O., and Petsiavas, D. N.
1956. EFFECT OF PHYSICAL VARIABLES ON MICROBIOLOGICAL TRANSFORMATION OF STEROIDS.
Ind. Eng. Chem. 48: 2213-17.

Kirk, R. E. and Othmer, D. F.
1951. ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY.
Vol. 6. See article entitled FERMENTATION, by George I. de Becze, pp. 317-75. New York.

Kluyver, A. J., and Van Niel, C. B.
1956. THE MICROBE'S CONTRIBUTION TO BIOLOGY.
182 pp. Cambridge, Mass.

Mamoli, L.
1939. NEW RESULTS IN THE ENZYMATIC BIOCHEMISTRY OF THE REPRODUCTIVE-GLAND HORMONES.
Österr. Chem.-Ztg. 42: 190-4.

Neuberg, C.
1949. BIOCHEMICAL REDUCTIONS AT THE EXPENSE OF SUGARS. Chapter in Adv. Carbohyd. Chem. 4: 75-117.

Posternak, T., Rapin, A., and Haenni, A.-L.
1957. RESEARCH IN THE CYCLITOL SERIES. XXIV. ON THE RULES OF THE OXIDATION OF CYCLITOLS BY Acetobacter suboxydans. Helv. Chim. Acta 40: 1594-1603.

Prescott, S. C., and Dunn, C. G.
1949. INDUSTRIAL MICROBIOLOGY. ed. 2, 923 pp. New York.

Stodola, F. H.
1958. CHEMICAL TRANSFORMATIONS BY MICROORGANISMS.
134 pp. New York and London.

Thimann, K. V.
1955. THE LIFE OF BACTERIA. 775 pp. New York.

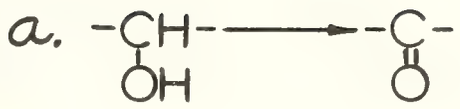
Todd, A. R.
1956. PERSPECTIVES IN ORGANIC CHEMISTRY.
527 pp. New York. See Chapter by K. Folkers entitled, MICROORGANISMS IN ORGANIC CHEMISTRY. pp. 392-429.

Underkofler, L. A., and Hickey, R. J.
1954. INDUSTRIAL FERMENTATIONS. 2 vols. New York.

Werkman, C. H., and Wilson, P. W.
1951. BACTERIAL PHYSIOLOGY. 707 pp. New York.

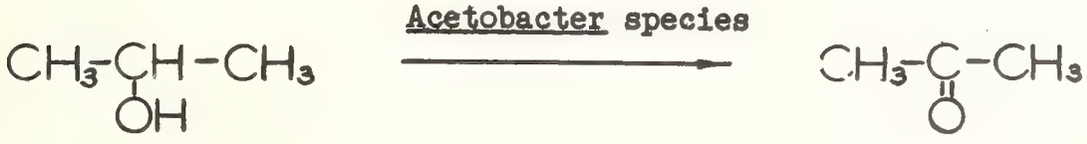
TYPE REACTIONS

I. Oxidation

a. 

Visser't Hooft, "Biochemische onderzoekingen over het Geslacht Acetobacter." Thesis, Delft (1925).

Rx. 1

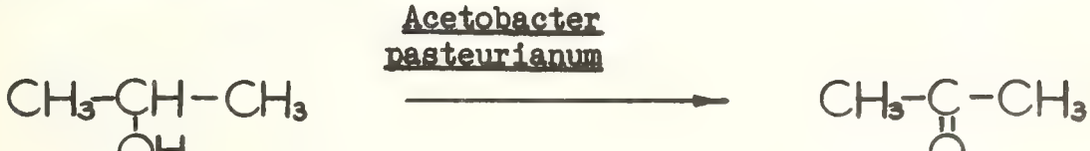


2-propanol (isopropyl alcohol) → acetone

Müller, Biochem. Z. 238, 253-67 (1931).

C.A. 25, 5687[9] (1931).

Rx. 2

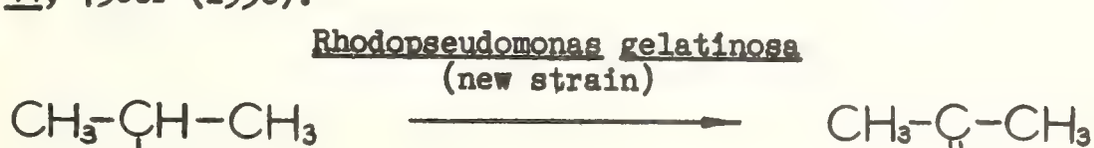


2-propanol → acetone (75-100%)

Siegel and Kamen, J. Bacteriol. 59, 693-7 (1950).

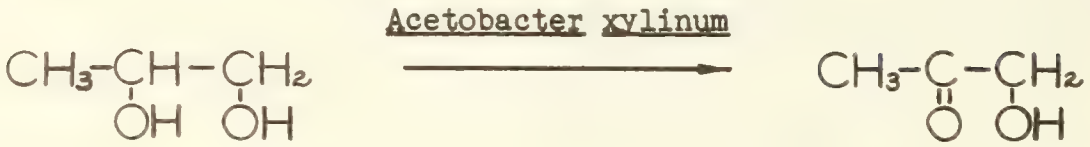
C. A. 44, 7380f (1950).

Rx. 3



2-propanol → acetone (42%)

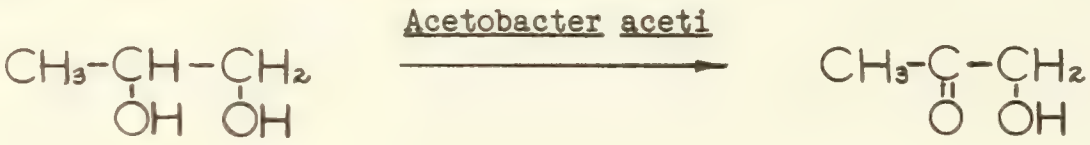
Kling, Compt. rend. 128, 244-6 (1899).
Brit. C. A. 76 [i], 323 (1899).
Rx. 4



1,2-propanediol
(1,2-propylene glycol)

acetol (10%)

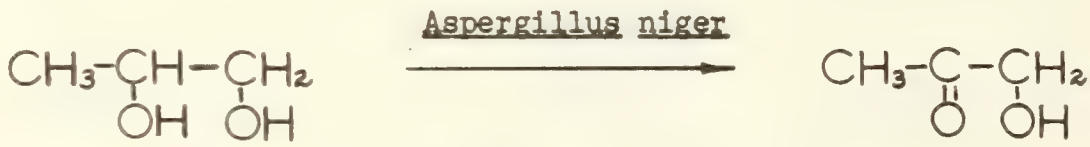
Kling, Compt. rend. 133, 231-3 (1901).
Brit. C.A. 80 [i], 625 (1901).
Rx. 5



1,2-propanediol

acetol

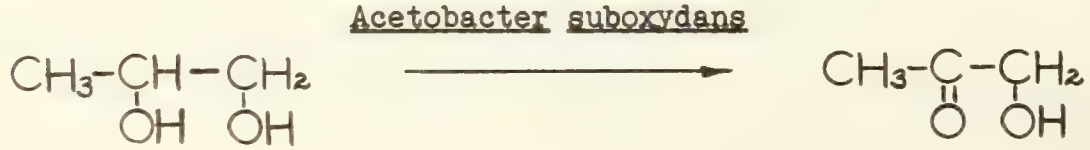
Walti, J. Am. Chem. Soc. 56, 2723-6 (1934).
C.A. 29, 731[4] (1935).
Rx. 6



1,2-propanediol

acetol

Butlin and Wince, J. Soc. Chem. Ind. 58, 365-6 (1939).
C.A. 34, 2412[9] (1940).
Rx. 7

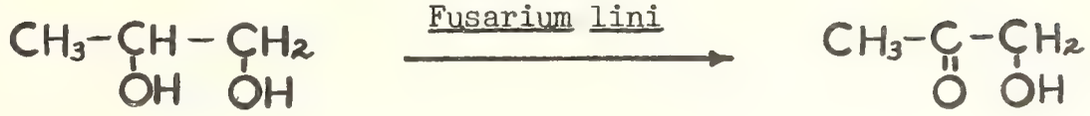


1,2-propanediol

acetol (nearly 100%)

Goepfert, J. Biol. Chem. 140, 525-34 (1941).
C.A. 35, 6618[1] (1941).

Rx. 8

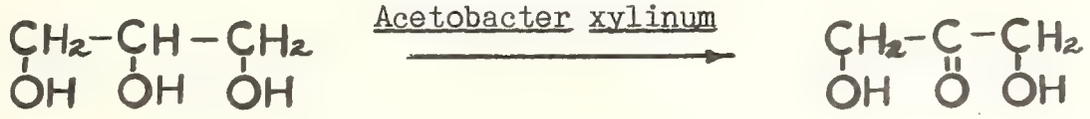


1,2-propanediol
(1,2-propylene glycol)

acetol (10-13%)

Bertrand, Compt. rend. 126, 842-4; 984-6 (1898).
Brit. C.A. 74 [i], 556 (1898).

Rx. 9

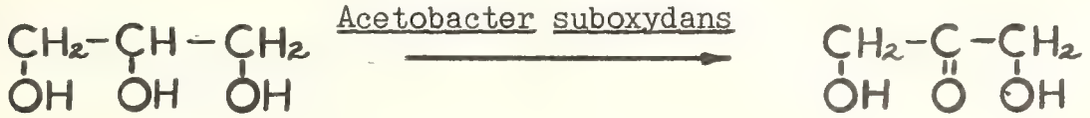


glycerol

dihydroxyacetone (30%)

Visser't Hooft, "Biochemische onderzoekingen over het Geslacht Acetobacter." Thesis, Delft (1925).

Rx. 10

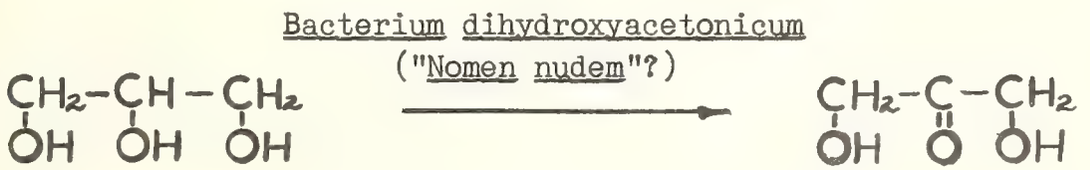


glycerol

dihydroxyacetone

Virtanen and Bärlund, Biochem. Z. 169, 169-77 (1926).
C.A. 20, 3307[8] (1926).

Rx. 11



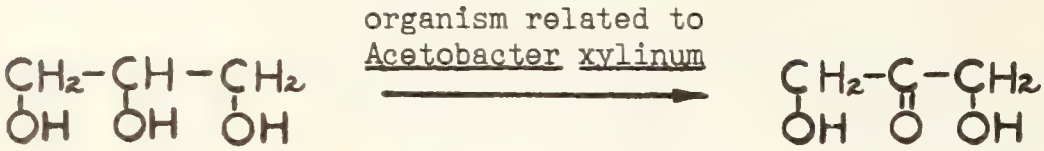
glycerol

dihydroxyacetone (84%)

Bernhauer and Schön, Z. physiol. Chem. 177, 107-24 (1928).

C.A. 22, 3901[9] (1928).

Rx 12

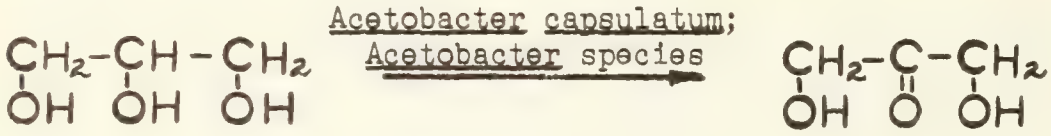


glycerol — dihydroxyacetone (nearly 100%)

Bousfield et al., J. Inst. Brewing 53, 258-62 (1947).

C.A. 42, 1381e (1948).

Rx. 13

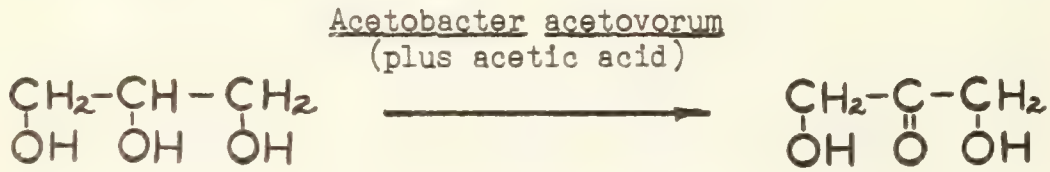


glycerol — dihydroxyacetone (80-100%)

Loĭtsyanskaya, Mikrobiologiya 22, 263-6 (1953).

C.A. 47, 12523i (1953).

Rx. 14

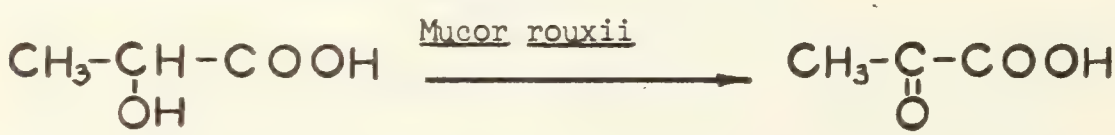


glycerol — dihydroxyacetone

Mazé and Ruot, Compt. rend. soc. biol. 79, 706-10 (1916).

C.A. 11, 976[2] (1917).

Rx. 15

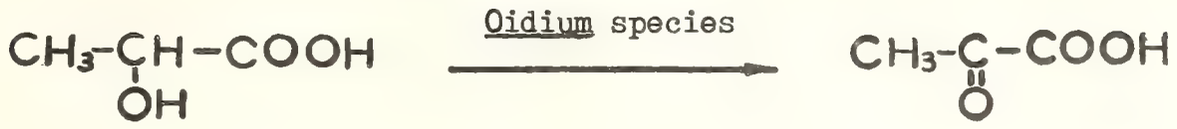


lactic acid — pyruvic acid (approx. 22%)

Mazé and Ruot, Compt. rend. soc. biol. 80, 336-9 (1917).

C.A. 11, 2585[4] (1917).

Rx. 16

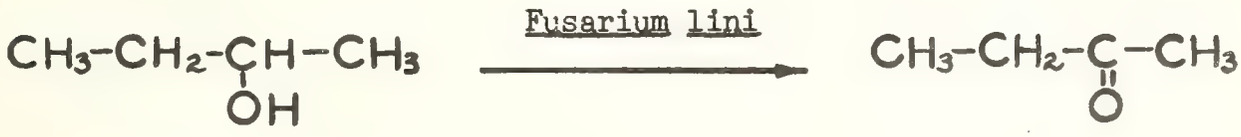


lactic acid — pyruvic acid (50%)

Goepfert, J. Biol. Chem. 140, 525-34 (1941).

C.A. 35, 6618[1] (1941).

Rx. 17

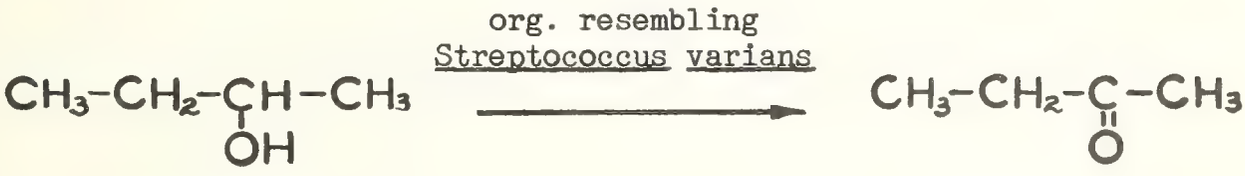


2-butanol — 2-butanone (17-20%) (methylethyl ketone)

Foster, J. Bacteriol. 47, 355-72 (1944).

C.A. 38, 4004[9] (1944).

Rx. 18

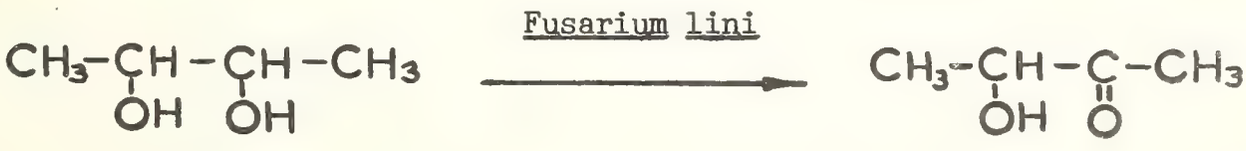


2-butanol — 2-butanone (100%)

Goepfert and Nord, Arch. Biochem. 1, 289-301 (1942).

C.A. 37, 1134[9] (1943).

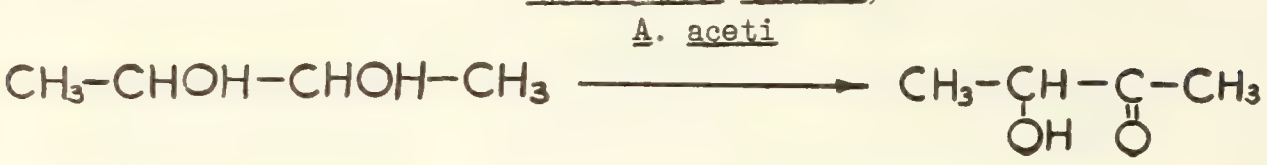
Rx. 19



2,3-butanediol (2,3-butylene glycol) — 3-hydroxy-2-butanone (25-30%) (acetylmethylcarbinol)

Grivsky, Bull. soc. chim. Belg. 51, 63-112 (1942).
C.A. 38, 3314[7] (1944).

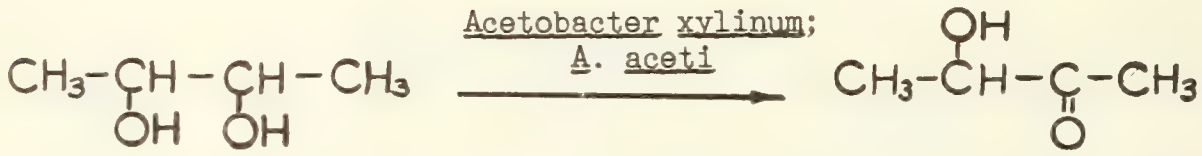
Rx. 20



D,L-2,3-butanediol — D (-) 3-hydroxy-2-butanone

Grivsky, Bull. soc. chim. Belg. 51, 63-112 (1942).
C.A. 38, 3314[7] (1944).

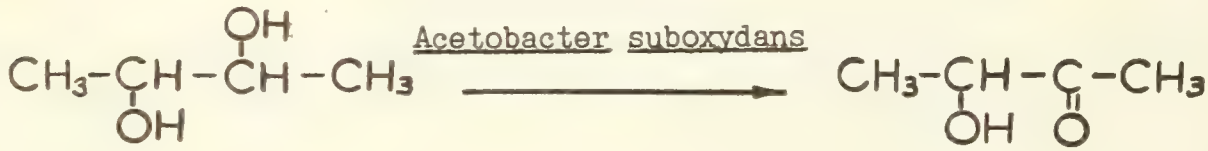
Rx. 21



meso-2,3-butanediol — L (+) 3-hydroxy-2-butanone

Underkofler et al., Iowa State Coll. J. Sci. 18, 377-9 (1944).
C.A. 38, 4749[2] (1944).

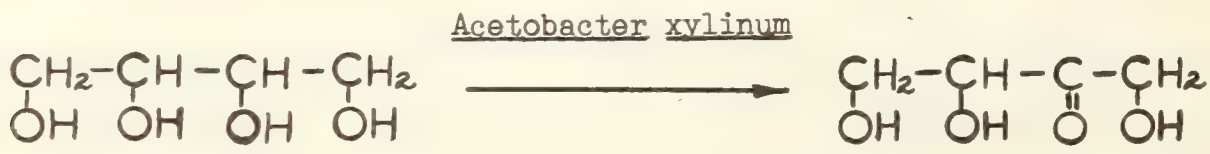
Rx. 22



D (-) 2,3-butanediol — D (-) 3-hydroxy-2-butanone (96%)
(See J. Am. Chem. Soc. 70, 990 (1948).

Bertrand, Compt. rend. 130, 1330-33 (1900).
Brit. C.A. 78 [i], 377 (1900).

Rx. 23

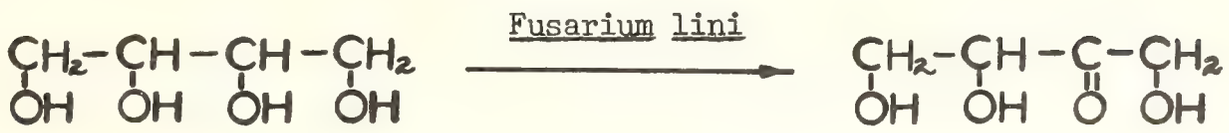


erythritol — erythrulose

Goepfert and Nord, Arch. Biochem. 1, 289-301 (1942).

C.A. 37, 1134[9] (1943).

Rx. 24

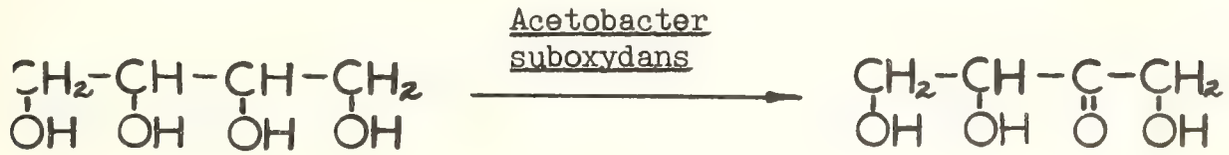


erythritol — erythrulose (3-4%)

Fulmer and Underkofler, Iowa State Coll. J. Sci. 21, 251-70 (1947).

C.A. 41, 6299e (1947).

Rx. 25

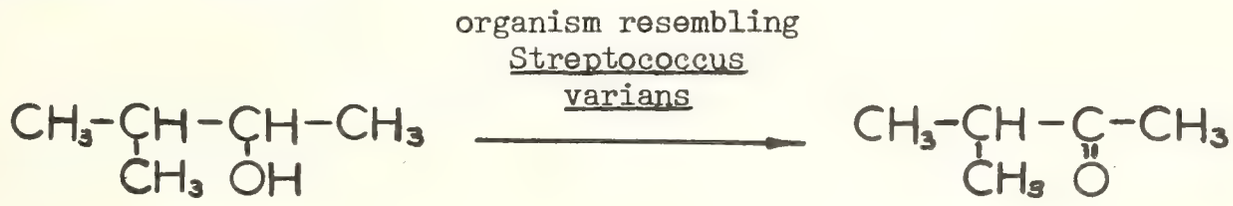


meso-erythritol — L-erythrulose (100%)

Foster, J. Bacteriol. 47, 355-72 (1944).

C.A. 38, 4004[9] (1944).

Rx. 26

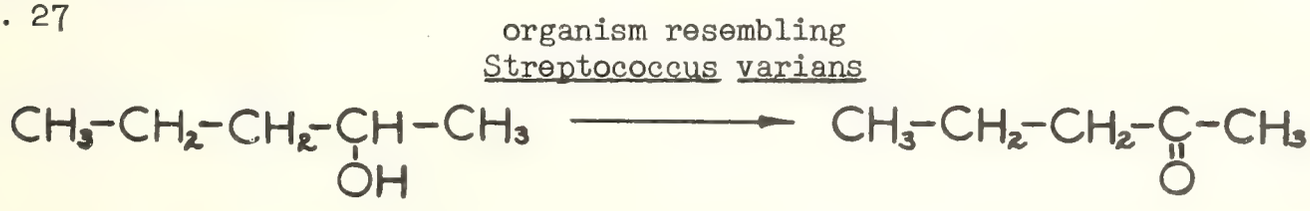


3-methyl-2-butanol — 3-methyl-2-butanone (100%)

Foster, J. Bacteriol. 47, 355-72 (1944).

C.A. 38, 4004[9] (1944).

Rx. 27

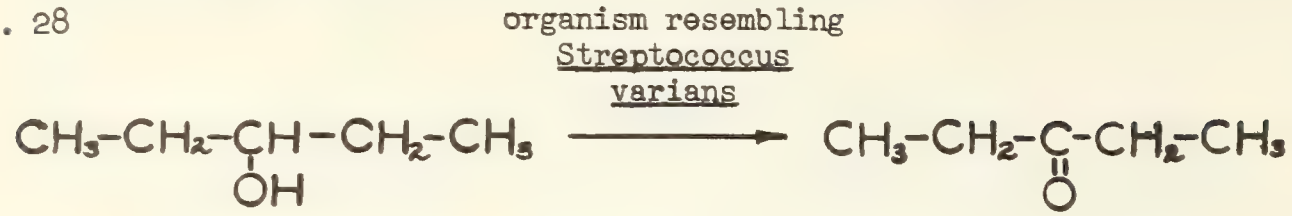


2-pentanol — 2-pentanone (100%)

Foster, J. Bacteriol. 47, 355-72 (1944).

C.A. 38, 4004[9] (1944).

Rx. 28

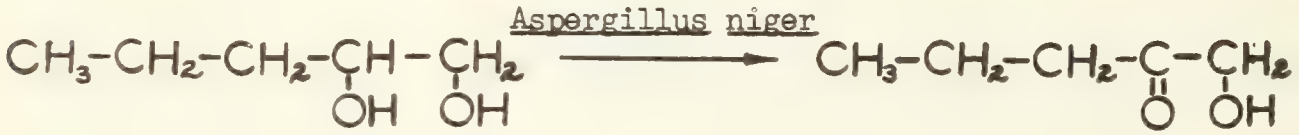


3-pentanol — 3-pentanone (100%)

Walti, J. Am. Chem. Soc. 56, 2723-6 (1934).

C.A. 29, 731[4] (1935).

Rx. 29

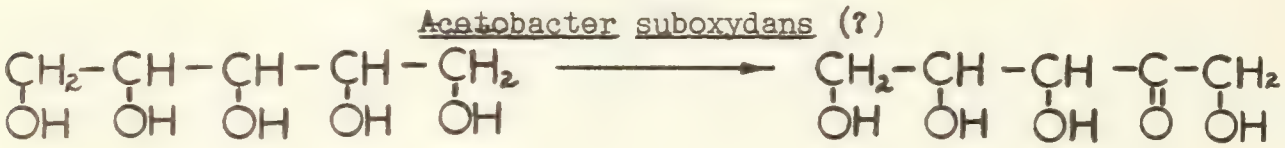


1,2-pentanediol — 1-hydroxy-2-pentanone

Reichstein, Helv. Chim. Acta 17, 996-1002 (1934).

C.A. 29, 1395[9] (1935).

Rx. 30

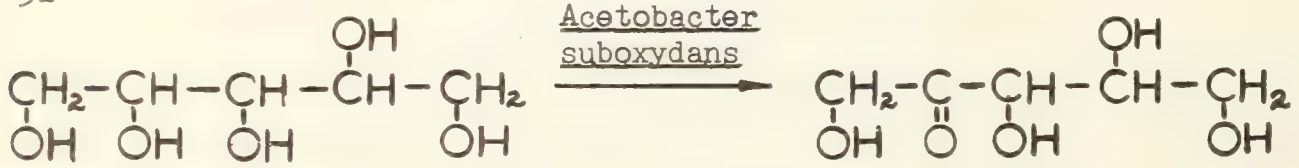


adonitol — L-adonulose (95%)

Hann et al., J. Am. Chem. Soc. 60, 1201-3 (1938).

C.A. 32, 5439[1] (1938).

Rx. 31

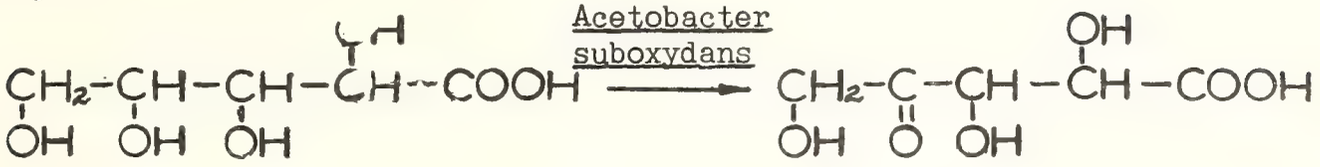


D-arabitol — D-xylulose

Liebster et al., Chem. Listy 47, 1075-80 (1953).

C.A. 48, 4044a (1954).

Rx. 32

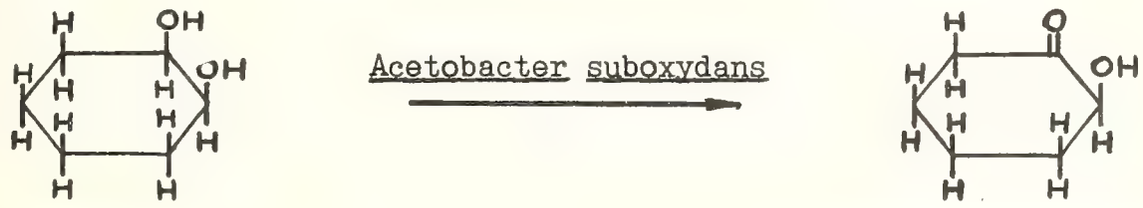


D-arabonic acid — 4-keto-D-arabonic acid (61%)

Posternak et al., Helv. Chim. Acta 38, 205-12 (1955).

C.A. 50, 1619e (1956).

Rx. 33

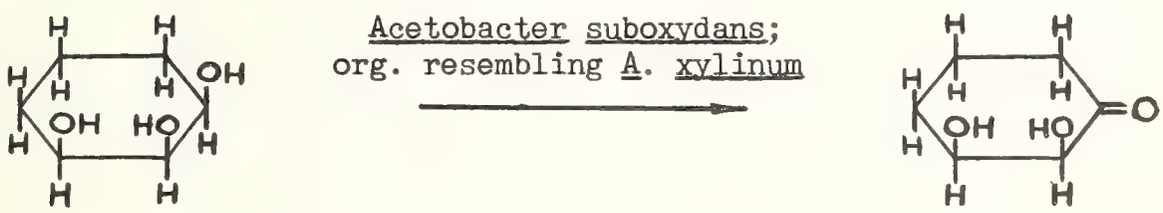


cis-cyclohexane-1,2-diol (1.8 g.) — 2-hydroxycyclohexanone (2.4 g. phenylhydrazone)

Posternak and Ravenna, Helv. Chim. Acta 30, 441-51 (1947).

C.A. 41, 3767h (1947).

Rx. 34

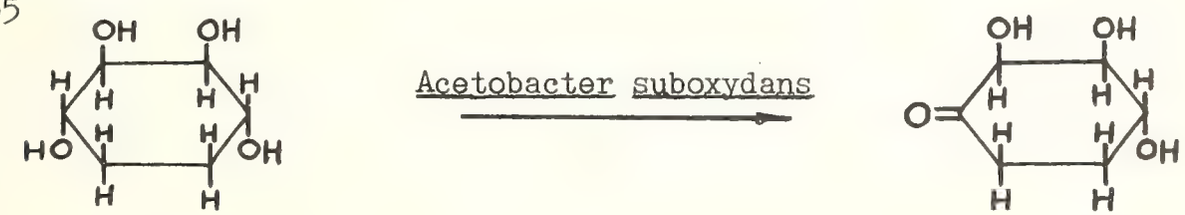


1,2,3-cyclohexanetriol (1.8 g.) — cis-2,3-dihydroxycyclohexanone (2.4 g. phenylhydrazone)

Posternak and Reymond, Helv. Chim. Acta 38, 195-205 (1955).

C.A. 50, 1618i (1956).

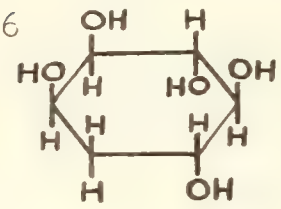
Rx. 35



dihydroconduritol — 2,3/4-trihydroxycyclohexanone

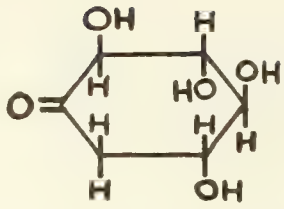
Posternak, Helv. Chim. Acta 33, 350-5 (1950).
C.A. 44, 6823g (1950).

Rx. 36



l-viburnitol

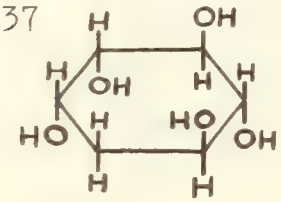
Acetobacter suboxydans



2,4/3,5-tetrahydroxy-cyclohexanone

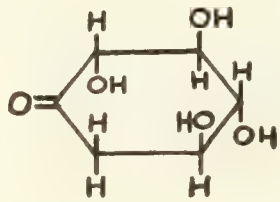
Posternak, Helv. Chim. Acta 33, 1594-7 (1950).
C.A. 45, 1967i (1951).

Rx. 37



d-viburnitol

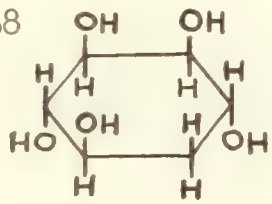
Acetobacter suboxydans



3,5/2,4-tetrahydroxy-cyclohexanone

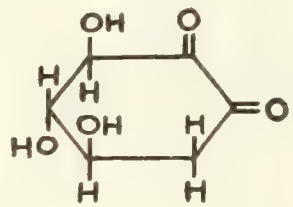
Magasanik and Chargaff, J. Biol. Chem. 175, 939-43 (1948).
C.A. 43, 4726h (1949).

Rx. 38



d-quercitol

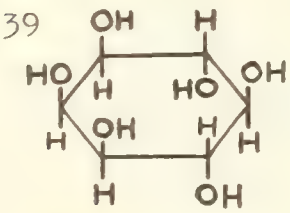
Acetobacter suboxydans



cyclohexane-1,5-cis-6-triol-2,3-dione

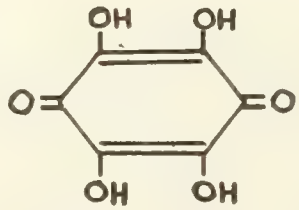
Kluyver et al., Enzymologia 7, 257-72 (1939).
C.A. 34, 6322[1] (1940).

Rx. 39



meso-inositol

Pseudomonas beijerinckii
(plus autoxidation)

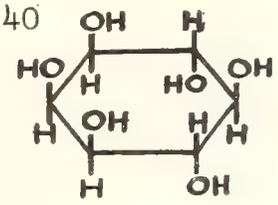


tetrahydrobenzoquinone

Posternak, Helv. Chim. Acta 25, 746-52 (1942).

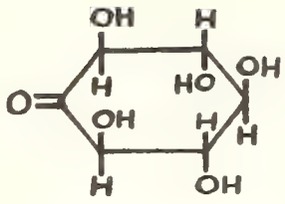
C.A. 37, 93^{8} (1943).

Rx. 40



meso-inositol

Acetobacter suboxydans

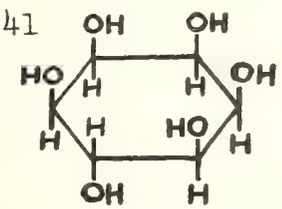


scyllo-ms-inosose

Posternak, Helv. Chim. Acta 29, 1991-8 (1946).

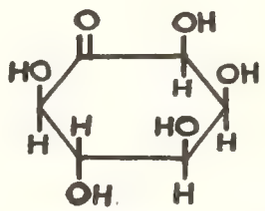
C.A. 41, 1623g, 5102f (1947).

Rx. 41



1-epi-inositol

Acetobacter suboxydans
Kluyver and de Leeuw

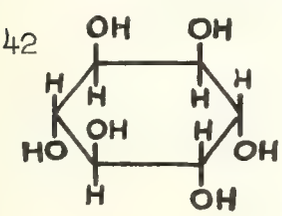


(-)epi-ms-inosose (68%)

Magasanik and Chargaff, J. Biol. Chem. 175, 929-37 (1948).

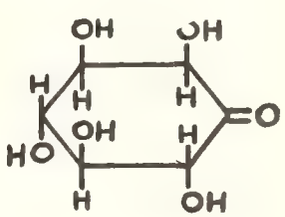
C.A. 43, 153b (1949).

Rx. 42



d-inositol

Acetobacter suboxydans

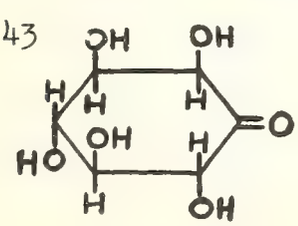


d-inosose

Magasanik and Chargaff, J. Biol. Chem. 175, 929-37 (1948).

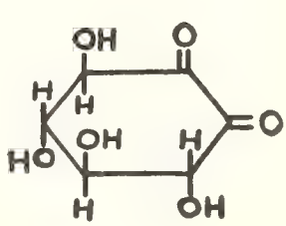
C.A. 43, 153b (1949).

Rx. 43



d-inosose

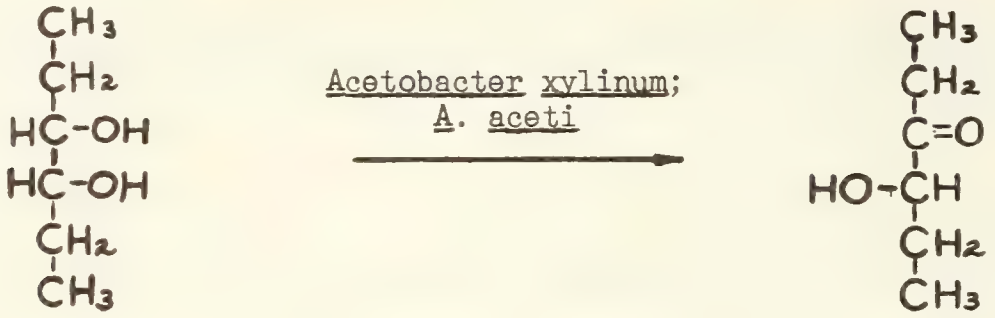
Acetobacter suboxydans



cyclohexane-1,5-cis-4,6-tetrol-2,3-dione

van Risseghem, Bull. soc. chim. Belg. 45, 21-35 (1936).
C.A. 30, 6705[6] (1936).

Rx. 44

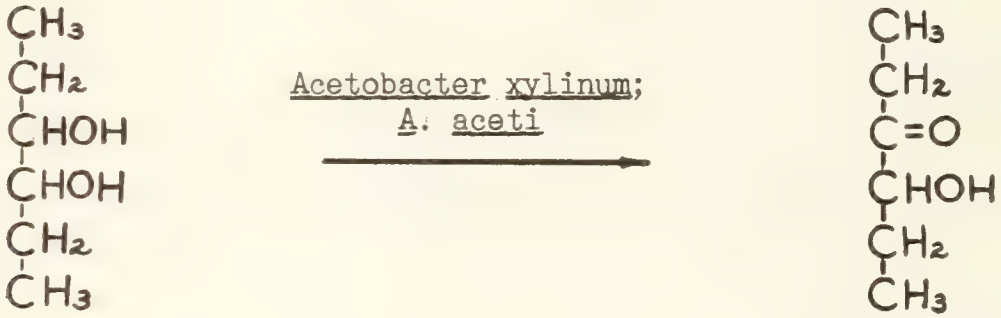


meso-3,4-hexanediol — L (+) 4-hydroxy-3-hexanone

---

van Risseghem, Bull. soc. chim. Belg. 45, 21-35 (1936).
C.A. 30, 6705[6] (1936).

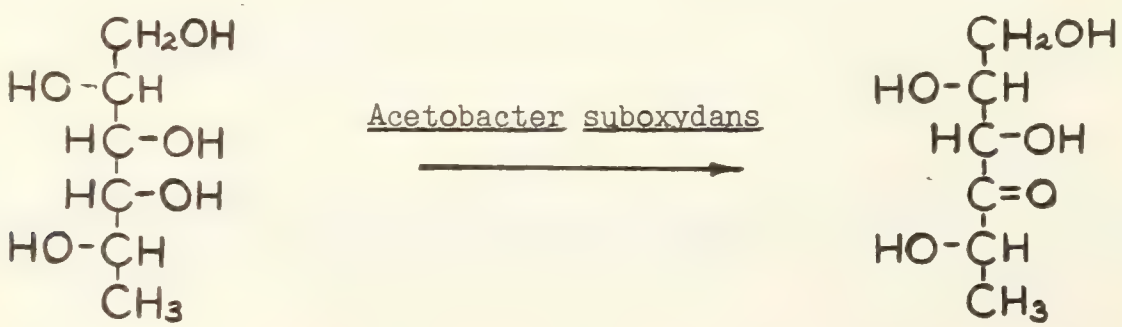
Rx. 45



D- or L-3,4-hexanediol — D- or L-4-hydroxy-3-hexanone

Richtmyer et al., J. Am. Chem. Soc. 72, 4934-7 (1950).
C.A. 45, 5109e (1951).

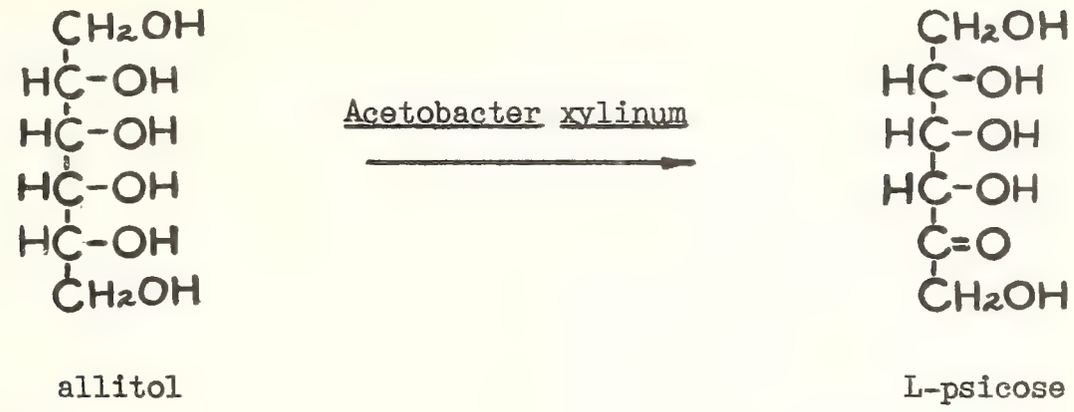
Rx. 46



L-fucitol — L-fuco-4-ketose

Steiger and Reichstein, Helv. Chim. Acta 18, 790-9 (1935).
C.A. 29, 6213[1] (1935).

Rx. 47



allitol — L-psicose

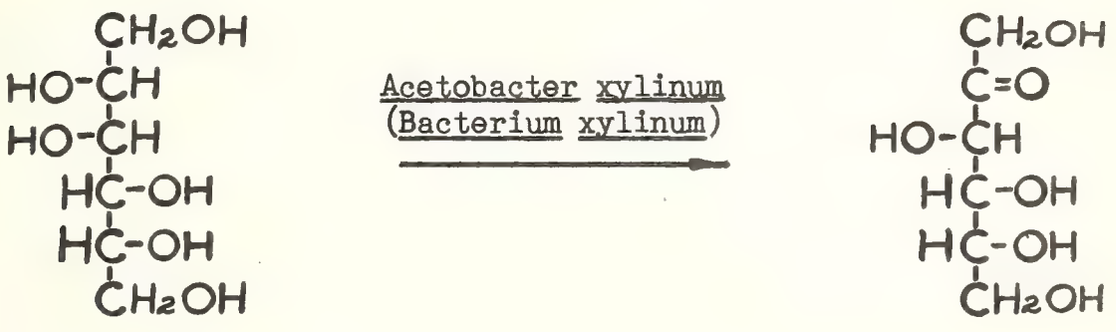
Brown, J. Chem. Soc. 49, 172-87 (1886).

Rx. 48

mannitol — fructose

Brown, J. Chem. Soc. 49, 432-9 (1886).

Rx. 49

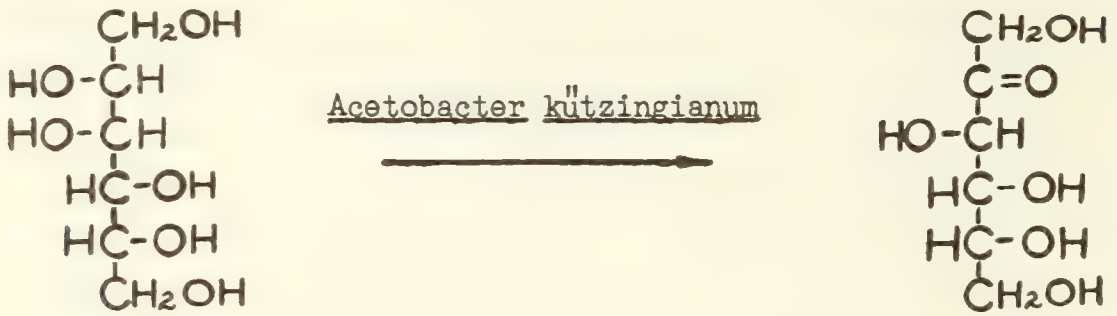


mannitol — fructose

Seifert, Zentr. Bakt. Parasitenk. [II] 3, 385-99 (1897).

Brit. C.A. 74, 399 (1898).

Rx. 50

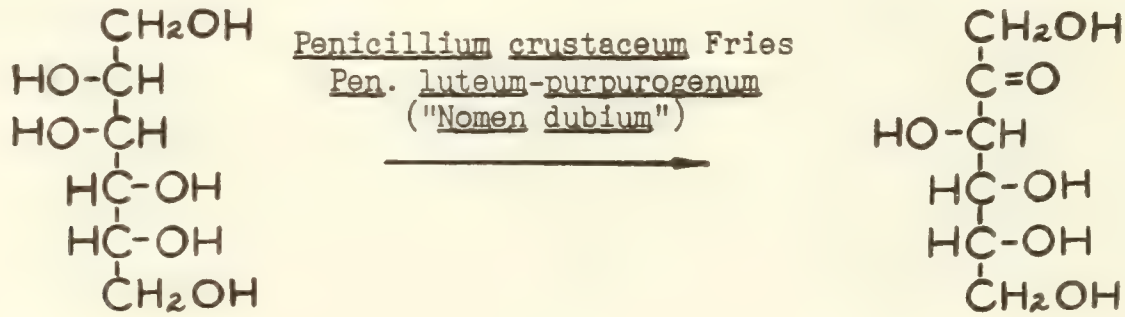


mannitol — fructose (0.26%)

Angeletti, Ann. chim. applicata 26, 234-6 (1936).

C.A. 30, 7612[7] (1936).

Rx. 51

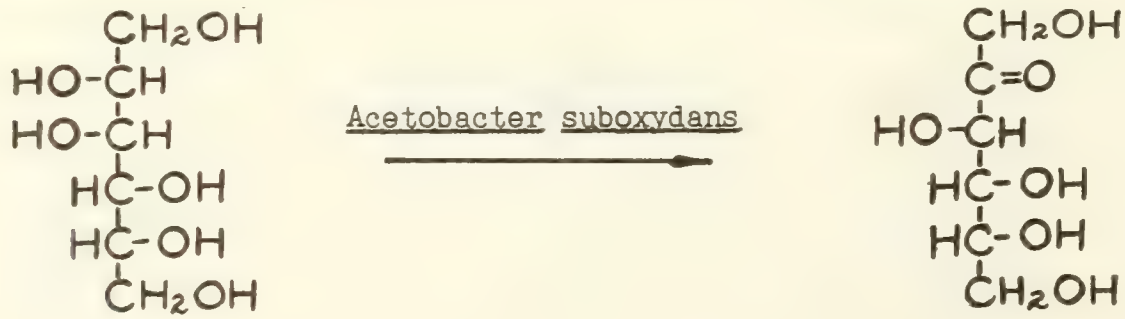


mannitol — fructose

Fulmer et al., Iowa State Coll. J. Sci. 13, 279-81 (1939).

C.A. 34, 128[3] (1940).

Rx. 52

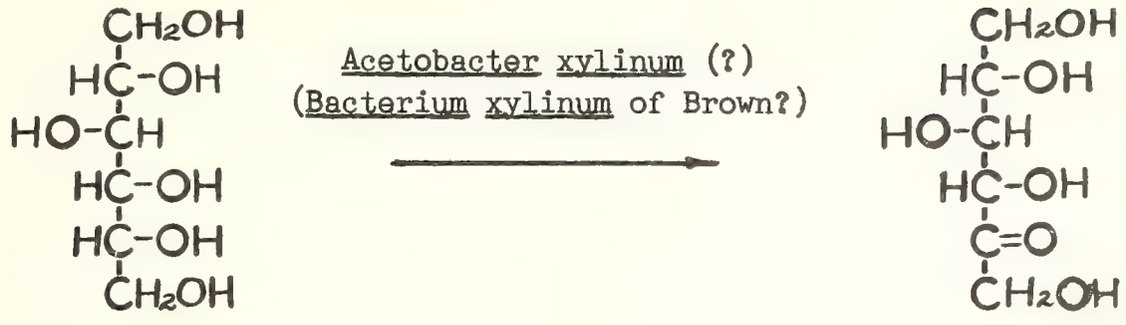


D-mannitol — D-fructose

Bertrand, Compt. rend. 122, 900-3 (1896).

Brit. C.A. /ii/, 494 (1896).

Rx. 53

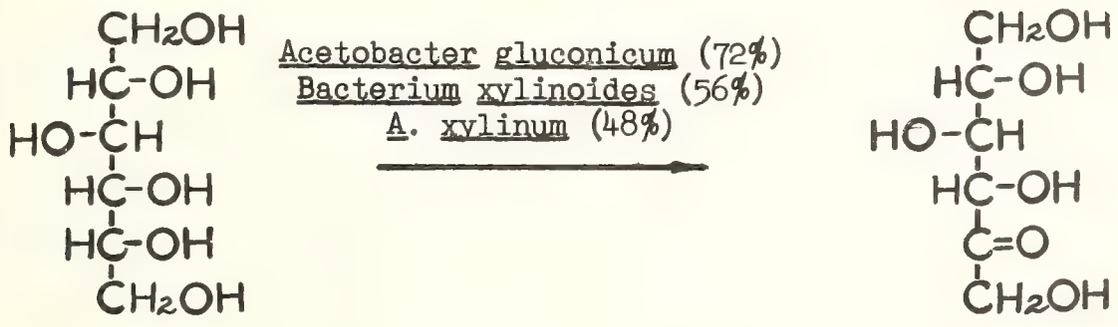


sorbitol — sorbose

Bernhauer and Görlich, Biochem. Z. 280, 375-8 (1935).

C.A. 30, 1085[3] (1936).

Rx. 54

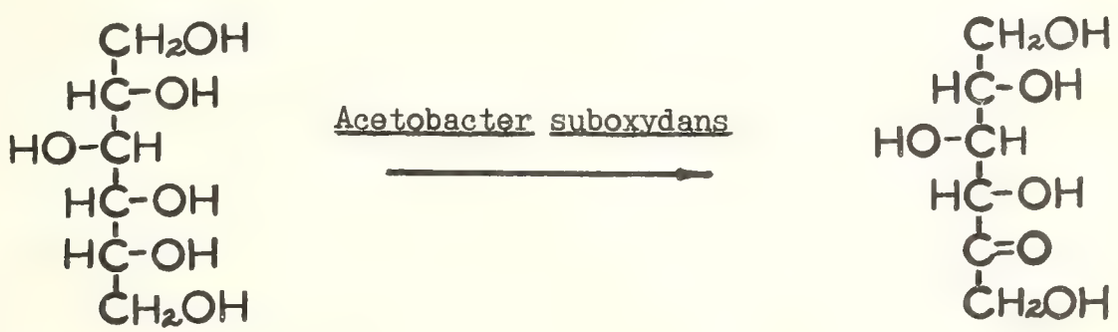


sorbitol — L-sorbose

Fulmer et al., J. Am. Chem. Soc. 58, 1012-13 (1936).

C.A. 30, 5260[3] (1936).

Rx. 55

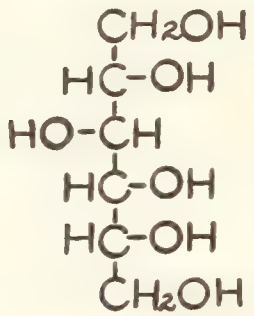


D-sorbitol — L-sorbose

Fulmer and Underkofler, Iowa State Coll. J. Sci. 21, 251-70 (1947).

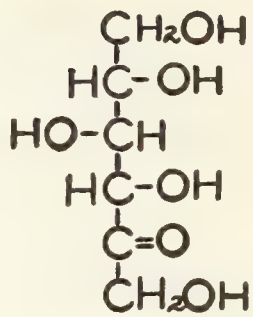
C.A. 41, 6299e (1947).

Rx. 56



D-sorbitol

Acetobacter aceti (85%)
A. xylinum (75%)
A. peroxydans (5%)

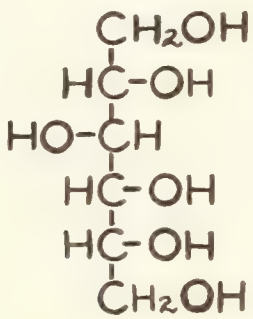


L-sorbose

Loĭtsyanskaya, Mikrobiologiya 22, 263-6 (1953).

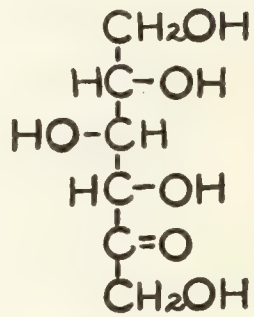
C.A. 47, 12523i (1953)

Rx. 57



sorbitol

Acetobacter acetovorum
(plus acetic acid)

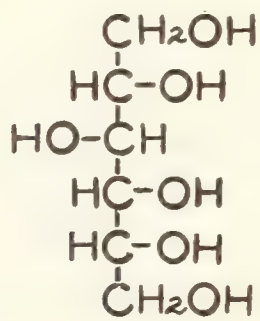


sorbose

Imshenetskiĭ and Kuzyurina, Mikrobiologiya 23, 159-65 (1954).

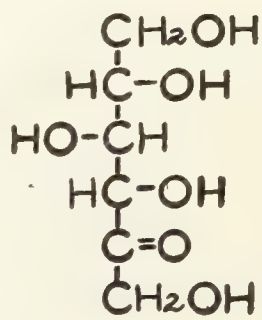
C.A. 48, 13821a (1954).

Rx. 58



sorbitol

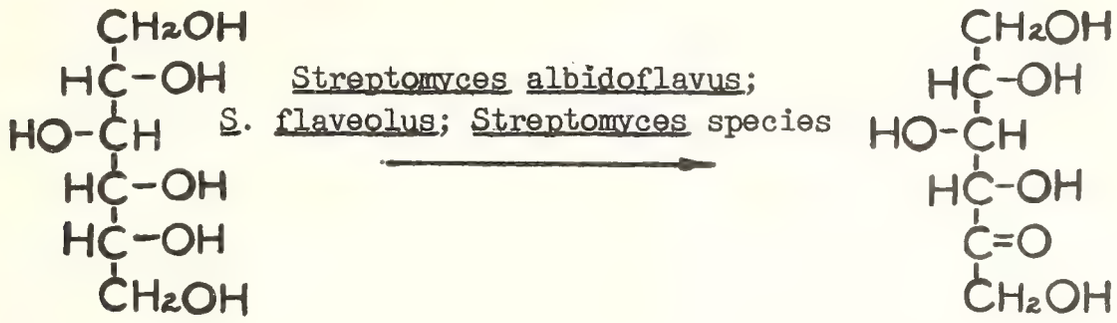
Acetobacter melanogenum;
A. suboxydans
(wrinkled strains)



sorbose

Masuo and Kondo, Ann. Rept. Shionogi Research Lab. No. 6, 115-17 (1956).
C.A. 51, 5192h (1957).

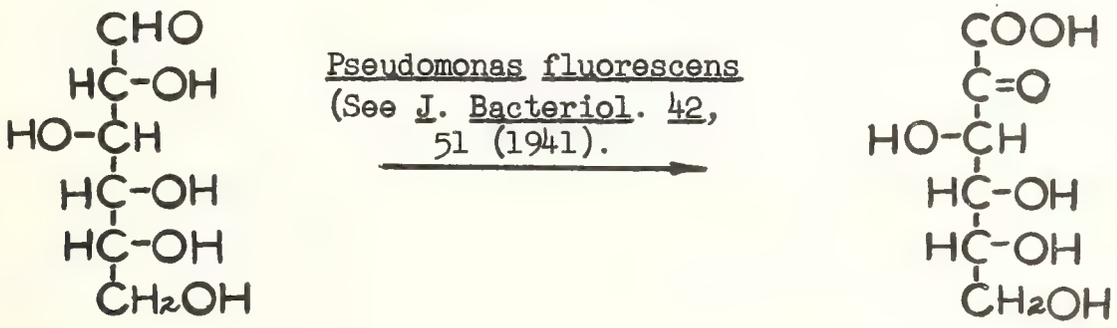
Rx. 59



D-sorbitol — L-sorbose (40%)

Stubbs et al., Ind. Eng. Chem. 32, 1626-31 (1940).
C.A. 35, 1575[8] (1941).

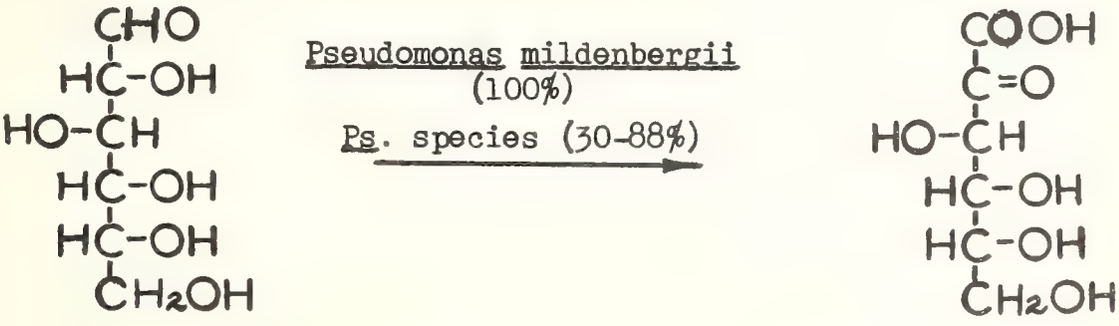
Rx. 60



D-glucose — 2-keto-D-gluconic acid (87%)

Lockwood et al., J. Bacteriol. 42, 51-61 (1941).
C.A. 35, 7449[9] (1941).

Rx. 61

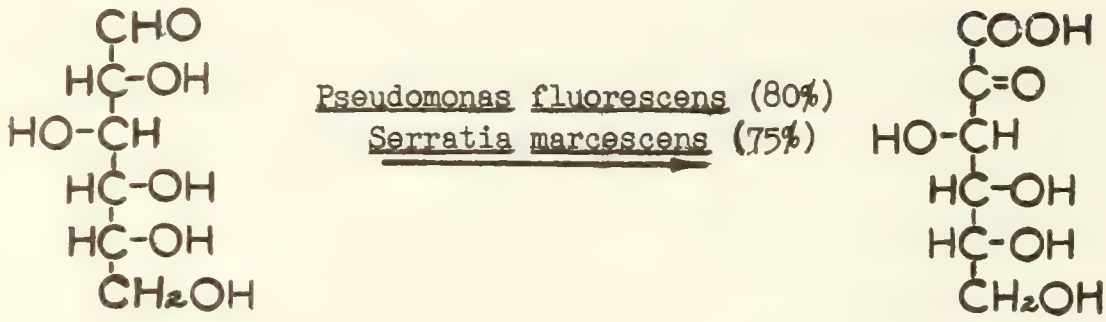


D-glucose — 2-keto-D-gluconic acid

Ikeda, J. Agr. Chem. Soc. Japan 24, 56-9 (1950).

C.A. 45, 7189g (1951).

Rx. 62

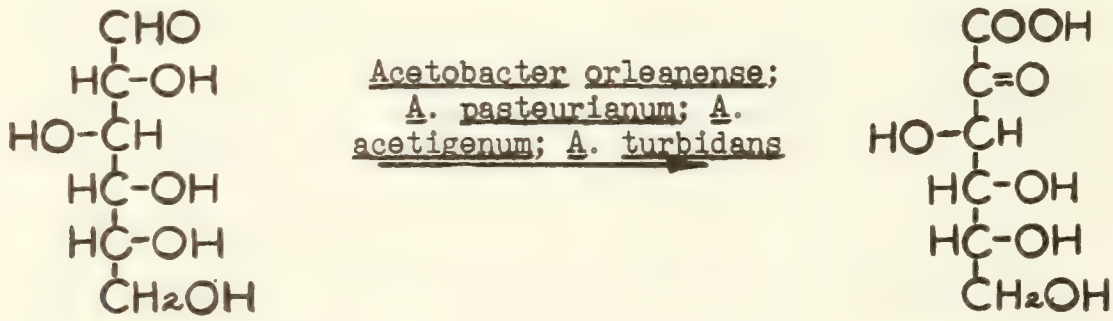


glucose — 2-ketogluconic acid

Kulka et al., Nature 167, 905-6 (1951).

C.A. reference not published (?)

Rx. 63

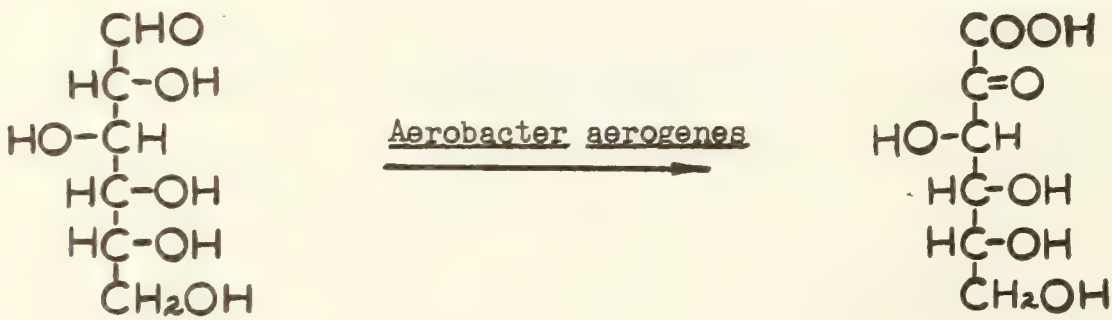


D-glucose — 2-keto-D-gluconic acid

Masuo and Nozaki, Ann. Repts. Shionogi Research Lab. No. 3, 97-101 (1953).

C.A. 50, 15711g (1956).

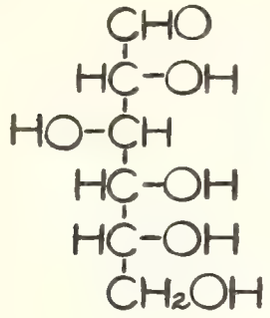
Rx. 64



D-glucose — 2-keto-D-gluconic acid

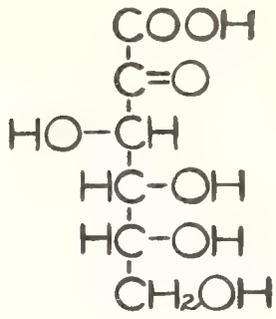
Kulka and Walker, Arch. Biochem. Biophys. 50, 169-79 (1954).
C.A. 48, 8870f (1954).

Rx. 65



glucose

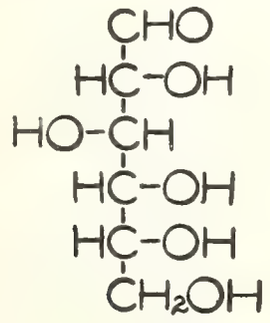
Acetobacter mobile;
A. gluconicum; A. xylinum;
other Acetobacter sp.



2-ketogluconic acid

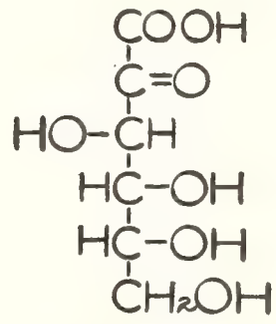
Blackwood and Blakley, Can. J. Microbiol. 2, 741-6 (1956).
C.A. 51, 2942b (1957).

Rx. 66



glucose

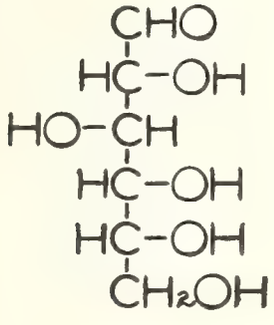
Xanthomonas uredovorus



2-keto-D-gluconic acid

Boutroux, Compt. rend. 102, 924-7 (1886).
Brit. C.A. [ii], 682 (1886).

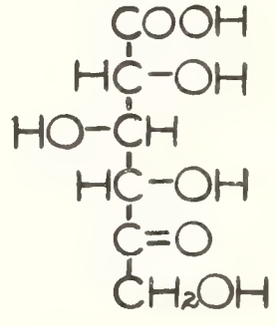
Rx. 67



glucose

organism resembling
Bacterium oblongum

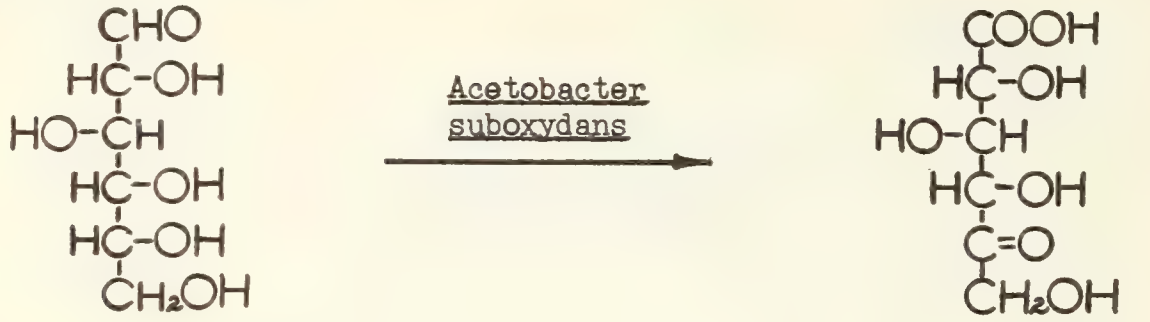
(M. oblongus)



"oxygluconic acid"
(probably 5-ketogluconic acid)

Kluyver and de Leeuw, Tijdschr. vergelijk. Geneeskunde 10, 170-82 (1924).
C.A. 18, 3202[6] (1924).

Rx. 68

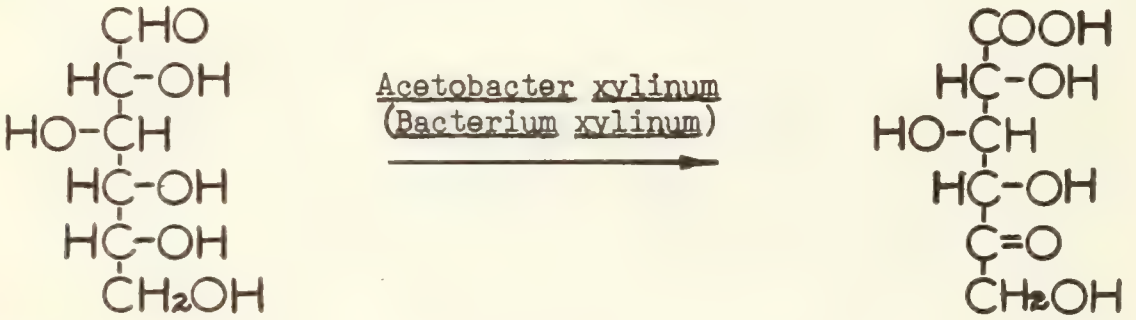


glucose

"oxygluconic acid" (shown later to be 5-ketogluconic acid)

Bernhauer and Schön, Z. physiol. Chem. 180, 232-40 (1929).
C.A. 23, 1924[5] (1929).

Rx. 69

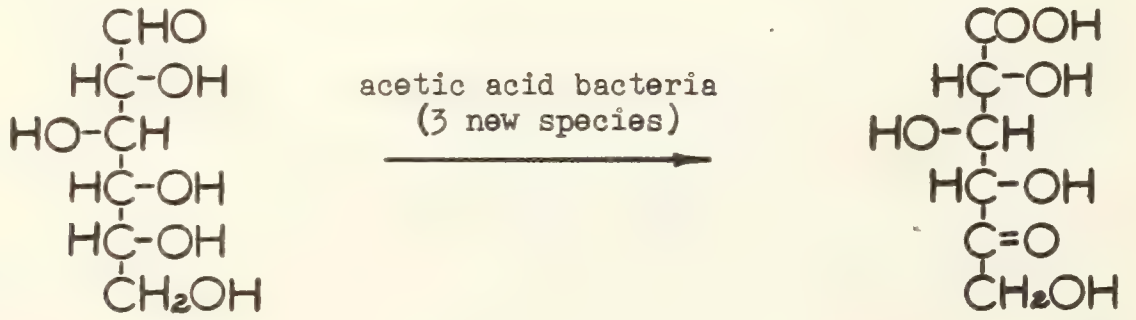


glucose

5-ketogluconic acid (65%)

Takahashi and Asai, J. Agr. Chem. Soc. Japan 6, 407-12 (1930).
C.A. 24, 4319[2] (1930).

Rx. 70



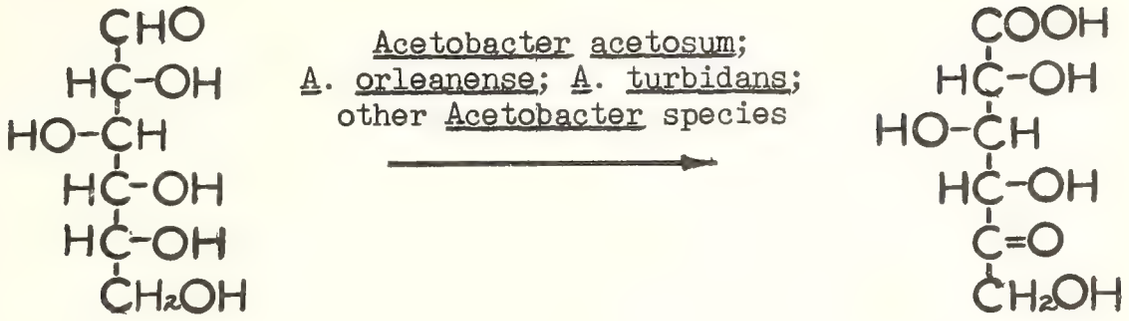
glucose

5-ketogluconic acid

Kulka et al., Nature 167, 905-6 (1951).

C.A. reference not available

Rx. 71



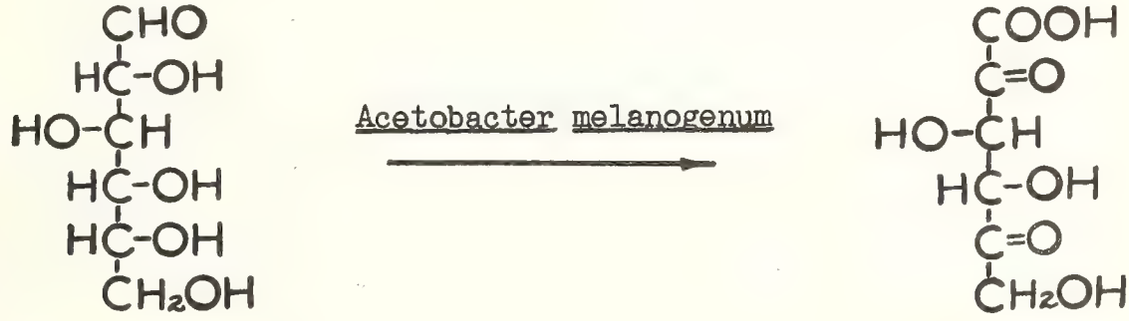
D-glucose

5-keto-D-gluconic acid

Katznelson et al., J. Biol. Chem. 204, 43-59 (1953).

C.A. 47, 12520h (1953).

Rx. 72



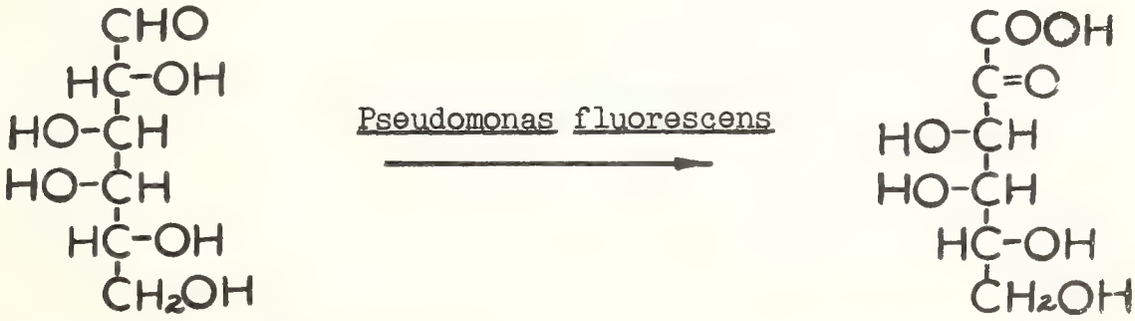
glucose

2,5-diketogluconic acid

Asai et al., J. Agr. Chem. Soc. Japan 26, 625-30 (1952).

C.A. 48, 12882f (1954).

Rx. 73

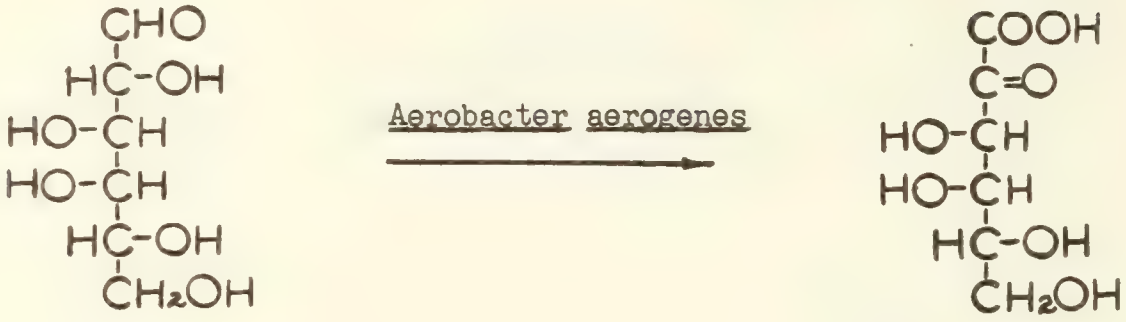


galactose

2-ketogalactonic acid

Masuo and Nozaki, Ann. Rept. Shionogi Research Lab. No. 6, 110-14 (1956).
C.A. 51, 5192f (1957).

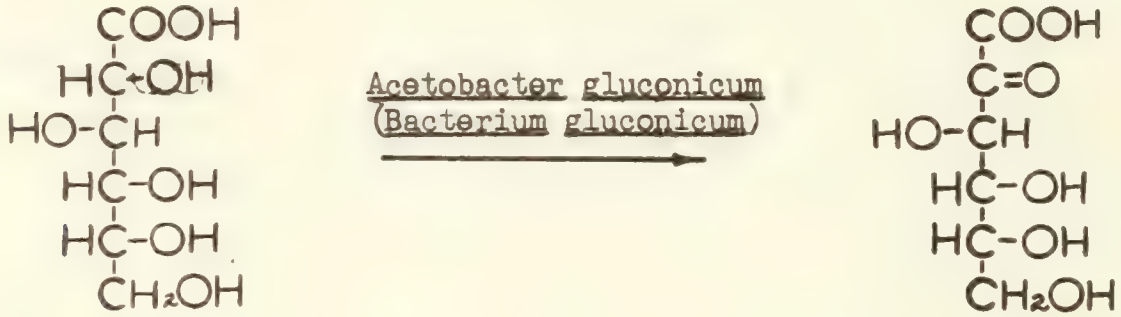
Rx. 74



D-galactose — 2-keto-D-galactonic acid

Bernhauer and Görlich, Biochem. Z. 280, 367-74 (1935).
C.A. 30, 10852 (1936).

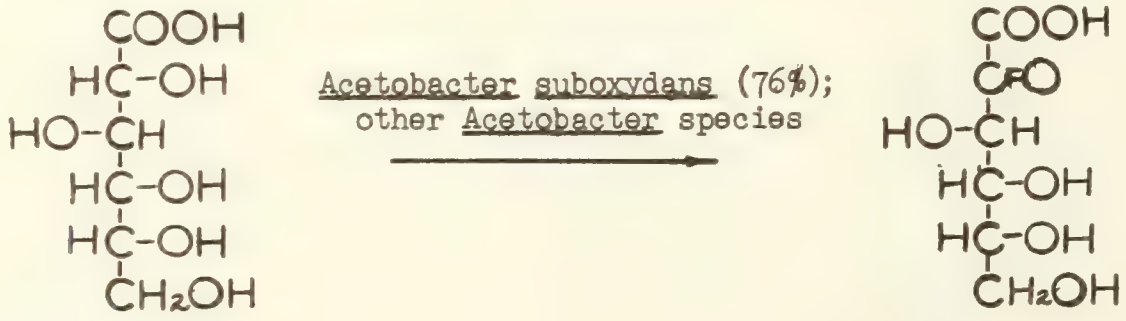
Rx. 75



gluconic acid — 2-ketogluconic acid (6%)

Bernhauer and Knobloch, Naturwissenschaften 26, 819 (1938).
C.A. 33, 42829 (1939).

Rx. 76

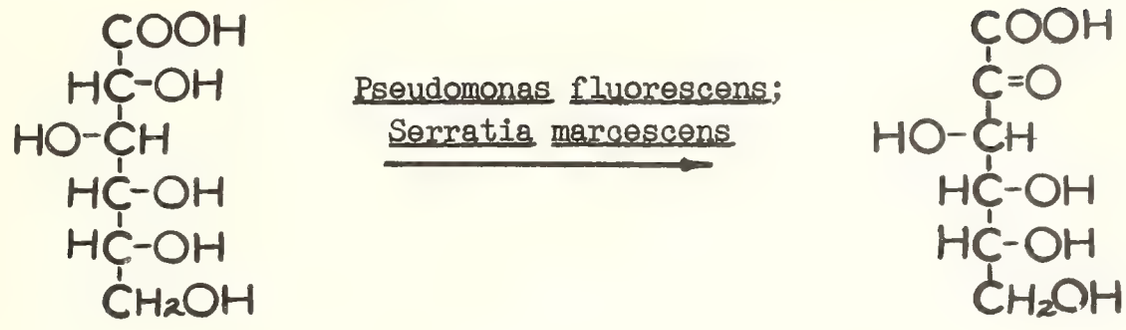


D-gluconic acid — 2-keto-D-gluconic acid

Ikeda, J. Agr. Chem. Soc. Japan 24, 51-55 (1950).

C.A. 45, 7189f (1951).

Rx. 77

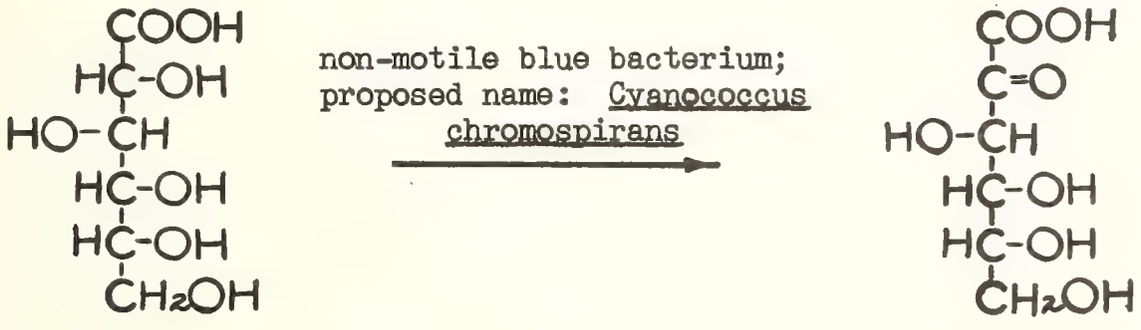


gluconic acid — 2-ketogluconic acid

Färber, Sborník Československ. Akad. Zemědělské 23, 355-64 (1951).

C.A. 45, 9605a (1951).

Rx. 78

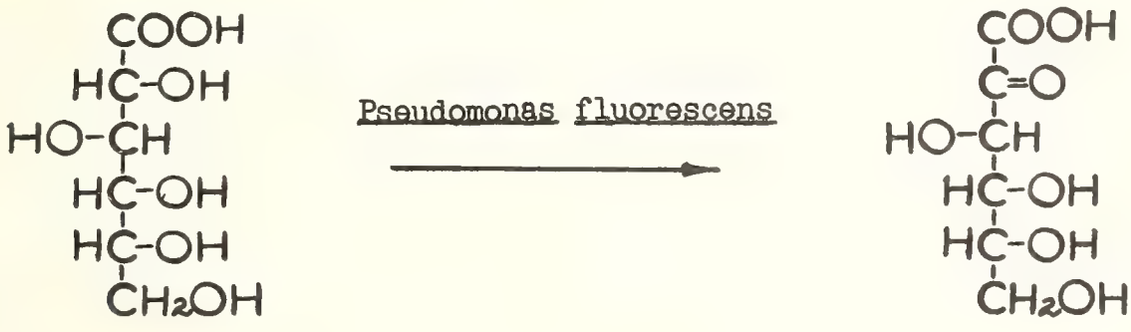


gluconic acid — 2-ketogluconic acid

Yamazaki, J. Fermentation Technol. (Japan) 31, 230-4 (1953).

C.A. 47, 7736e (1953).

Rx. 79

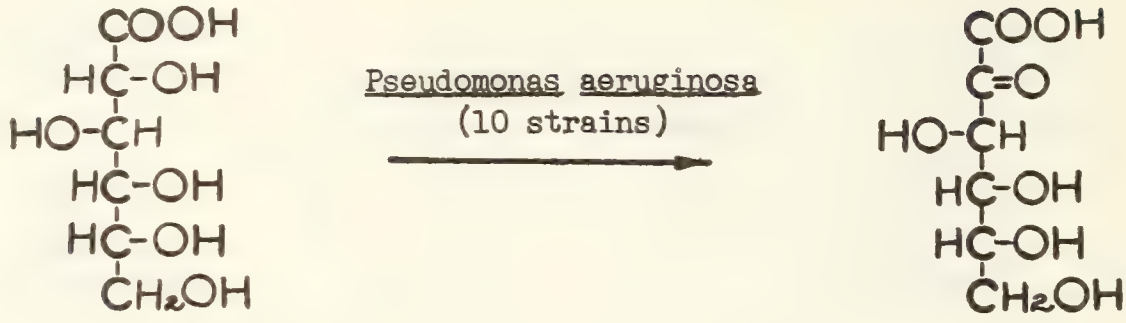


D-gluconic acid — 2-keto-D-gluconic acid (60%)

Kulhánek, Chem. Listy 47, 1071-4 (1953).

C.A. 48, 4043i (1954).

Rx. 80

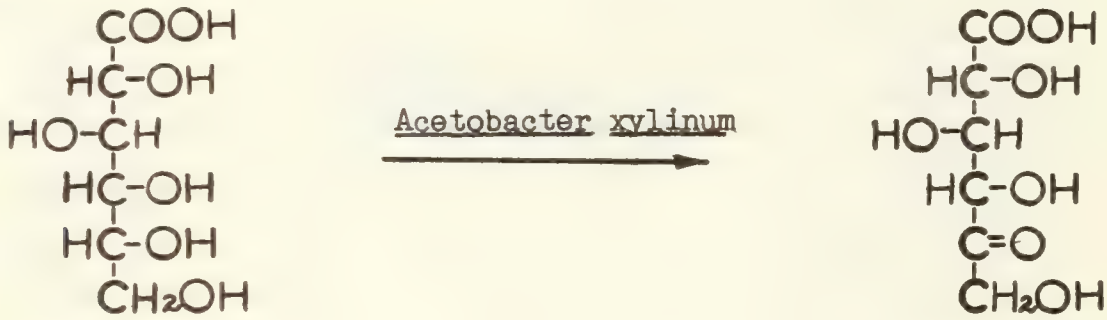


D-gluconic acid — 2-keto-D-gluconic acid (74%)

Bertrand, Ann. chim. phys. [8] 3, 181-288 (1904).

Brit. C.A. 86 [ii], 760 (1904).

Rx. 81

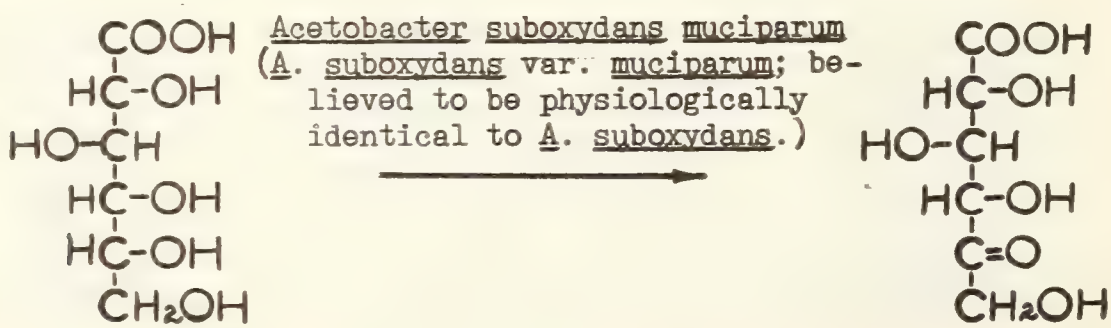


gluconic acid — 5-ketogluconic acid

Bernhauer and Knobloch, Biochem. Z. 303, 308-15 (1940).

C.A. 34, 4102[7] (1940).

Rx. 82

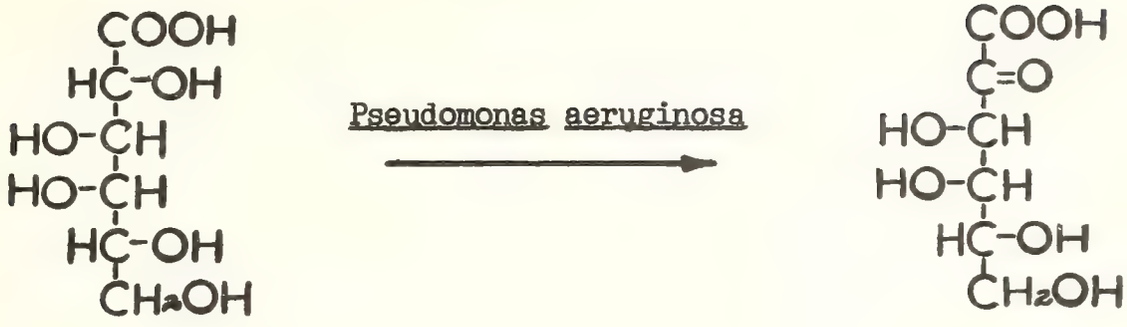


gluconic acid — 5-ketogluconic acid

Kulhánek, Chem. Listy 47, 1071-4 (1953).

C.A. 48, 4043i (1954).

Rx. 83



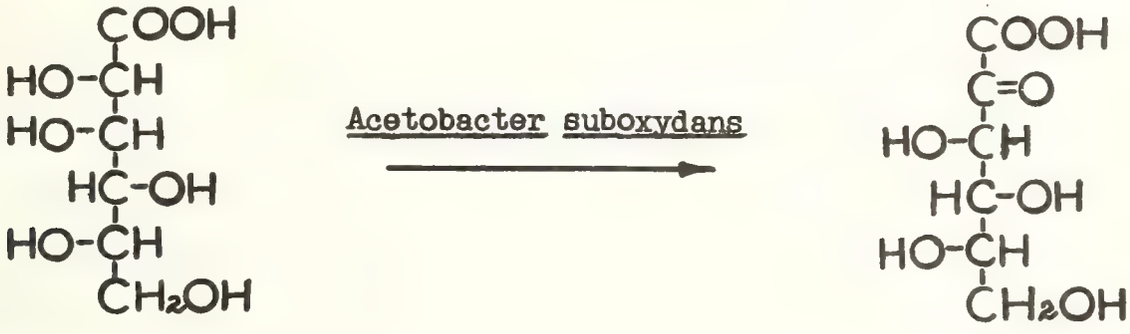
D-galactonic acid

2-keto-D-galactonic acid (82%)

Gray, U. S. 2,421,612 (June 3, 1947).

C.A. 41, 5684d (1947).

Rx. 84



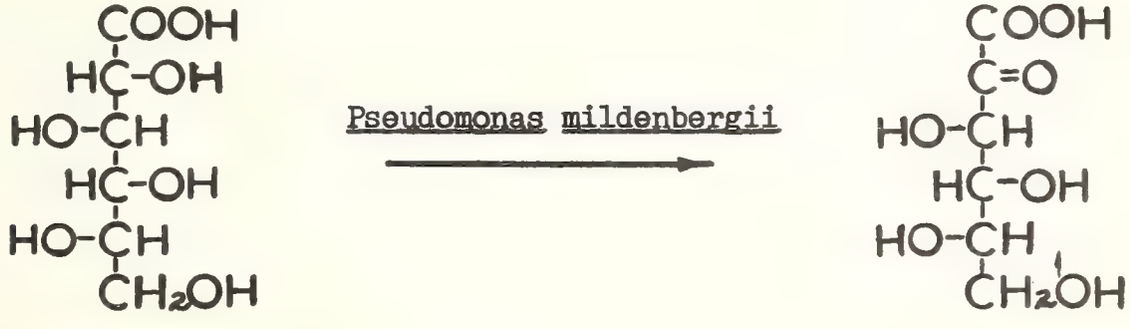
L-gulonic acid

2-keto-L-gulonic acid (about 75%)

Gray, U. S. 2,421,611 (June 3, 1947).

C.A. 41, 5683h (1947).

Rx. 85



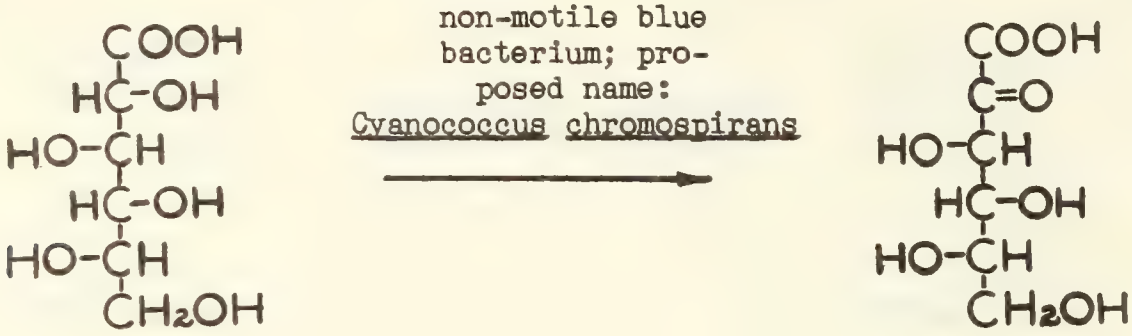
L-idonic acid

2-keto-L-idonic acid (about 45%)
(2-keto-L-gulonic acid)

Färber, Sborník Československ. Akad. Zemědělské 23, 355-64 (1951).

C.A. 45, 9605a (1951).

Rx. 86

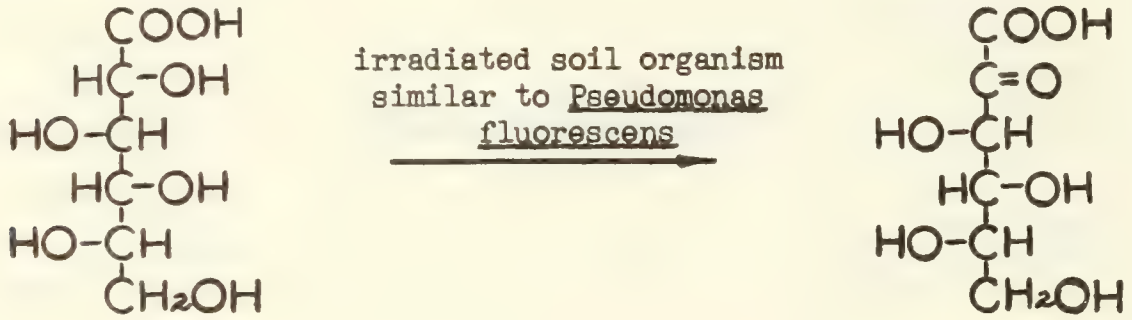


L-idonic acid — 2-keto-L-idonic acid

Hori and Nakatani, J. Fermentation Technol. (Japan) 31, 72-4 (1953).

C.A. 48, 5275d (1954).

Rx. 87

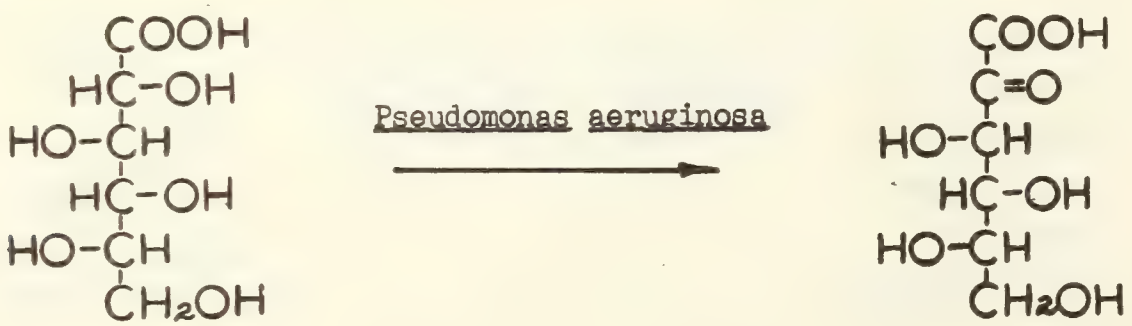


L-idonic acid — 2-keto-L-idonic acid

Kulhánek, Chem. Listy 47, 1071-4 (1953).

C.A. 48, 4043i (1954).

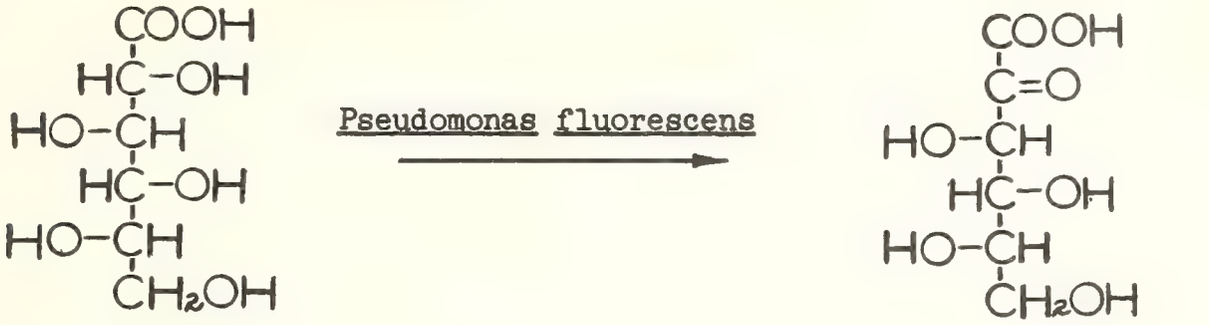
Rx. 88



L-idonic acid — 2-keto-L-idonic acid (90%)

Hori and Nakatani, J. Fermentation Technol. (Japan) 32, 33-6 (1954).
C.A. 48, 12885f (1954).

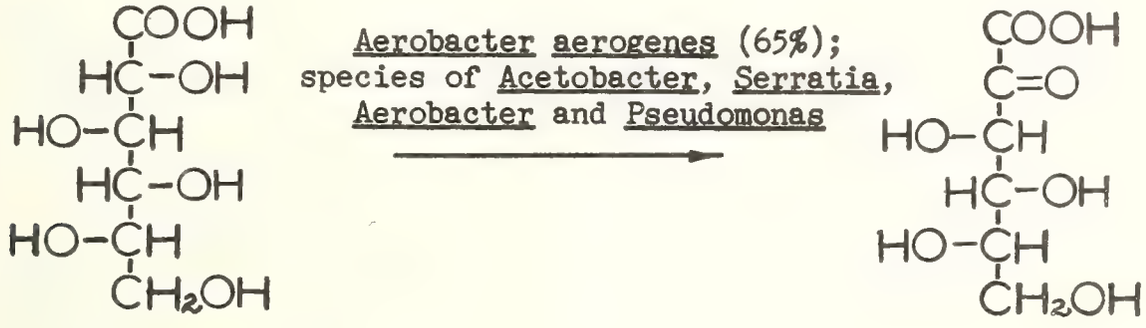
Rx. 89



L-idonic acid — 2-keto-L-idonic acid

Masuo et al., Ann. Repts. Shionogi Research Lab. No. 4, 62-8 (1954).
C.A. 50, 15711i (1956).

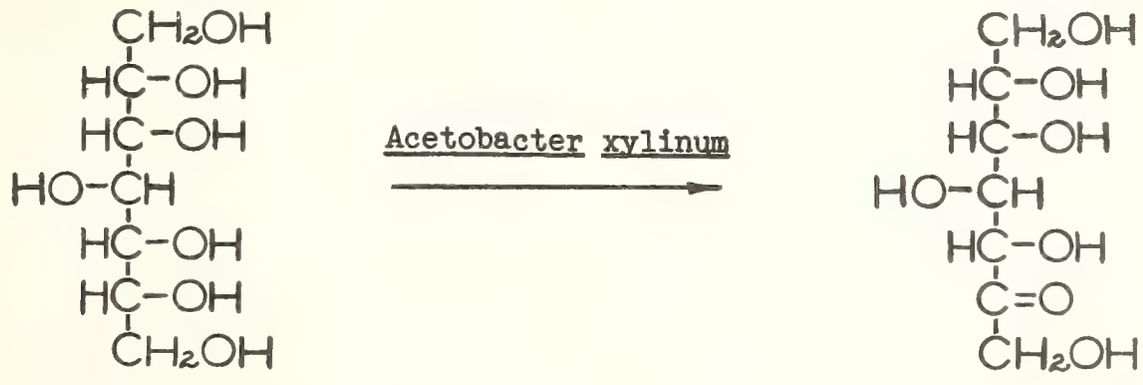
Rx. 90



L-idonic acid — 2-keto-L-idonic acid

Bertrand and Nitzberg, Compt. rend. 186, 925-8 (1928).
C.A. 22, 2178[3] (1928).

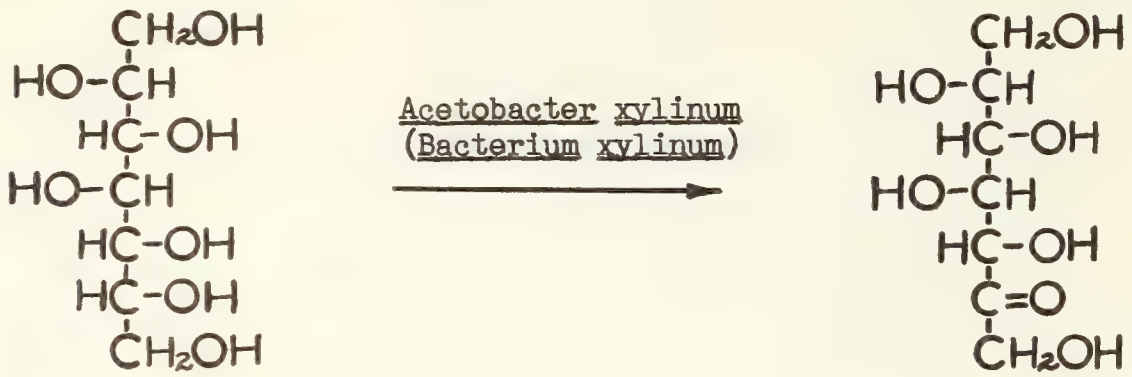
Rx. 91



α-glucoheptitol — L-glucoheptulose

Cozic, M. "Etude biochimique de Bact. xylinum." Doctoral Thesis. Andre Lesot, Nemours. (1933).
Houben-Weyl 4, 860 (1955). Pt. 2. 4th ed.

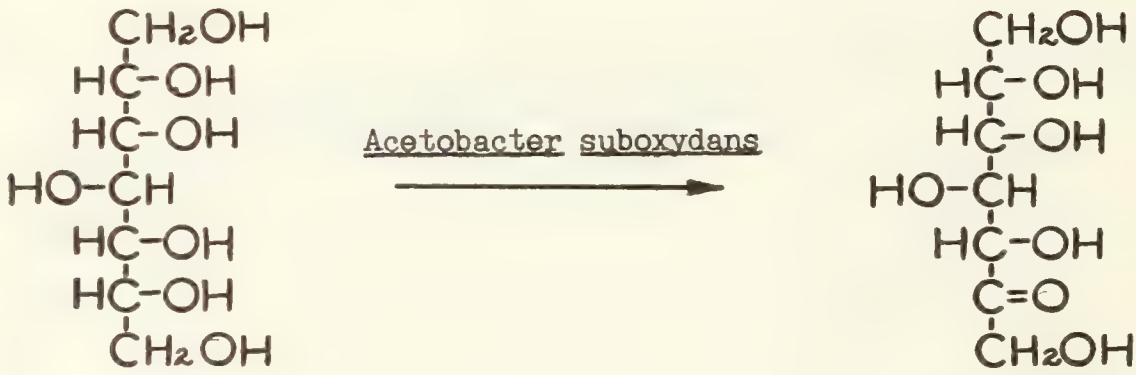
Rx. 92



D-β-glucoheptitol → D-idoheptulose

Hann et al., J. Am. Chem. Soc. 60, 1201-3 (1938).
C.A. 32, 5439[1] (1938).

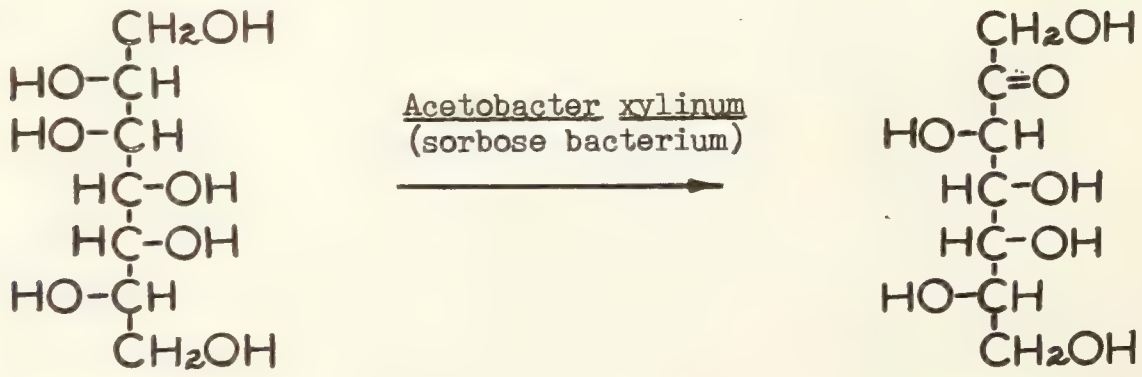
Rx. 93



α-glucoheptitol → L-glucoheptulose

Bertrand, Compt. rend. 147, 201-3 (1908).
C.A. 2, 3167[2] (1908).

Rx. 94

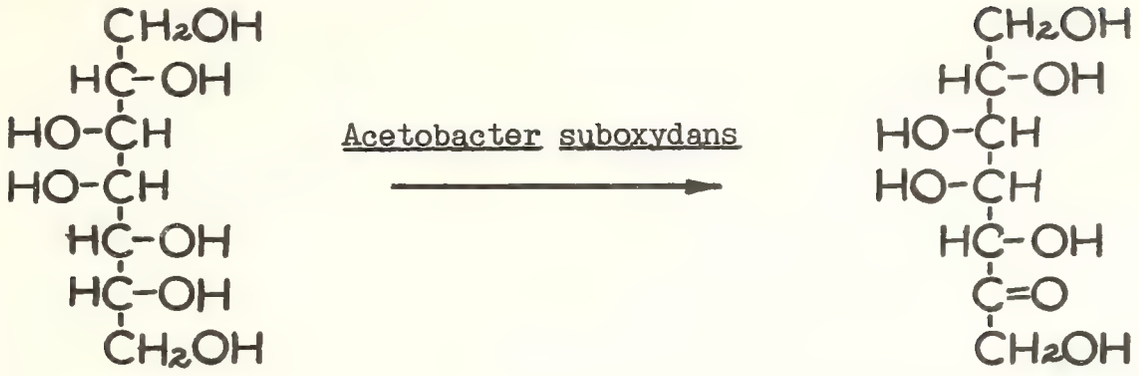


perseitol → perseulose (45%)

Hann et al., J. Am. Chem. Soc. 60, 1201-3 (1938).

C.A. 32, 5439[1] (1938).

Rx. 95

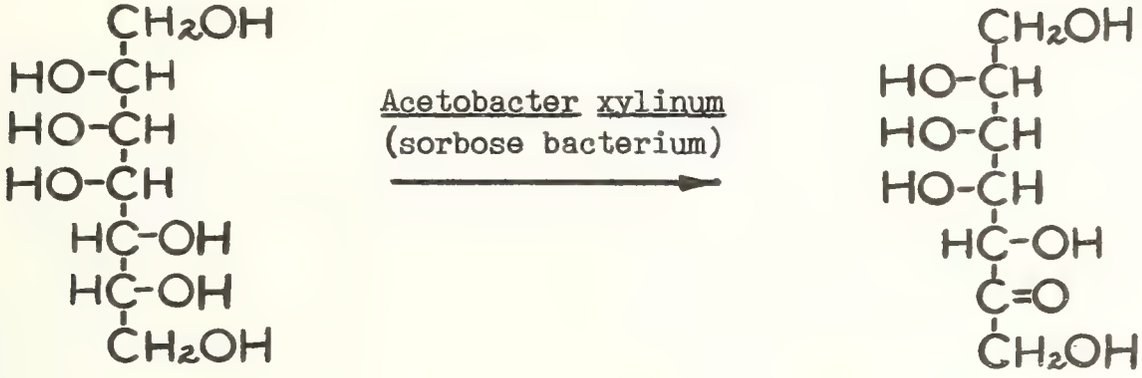


perseitol — perseulose (95-100%)

Bertrand, Compt. rend. 126, 762-5 (1898).

Brit. C.A. 74 [i], 550 (1898).

Rx. 96

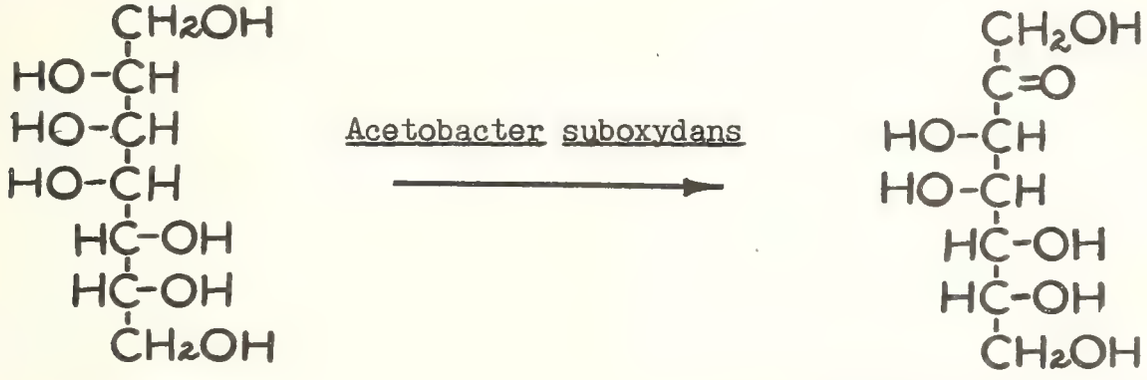


volemitol — volemulose (see JACS 71, 3532 (1949).

Stewart et al., J. Am. Chem. Soc. 71, 3532-4 (1949).

C.A. 44, 10799a (1950).

Rx. 97

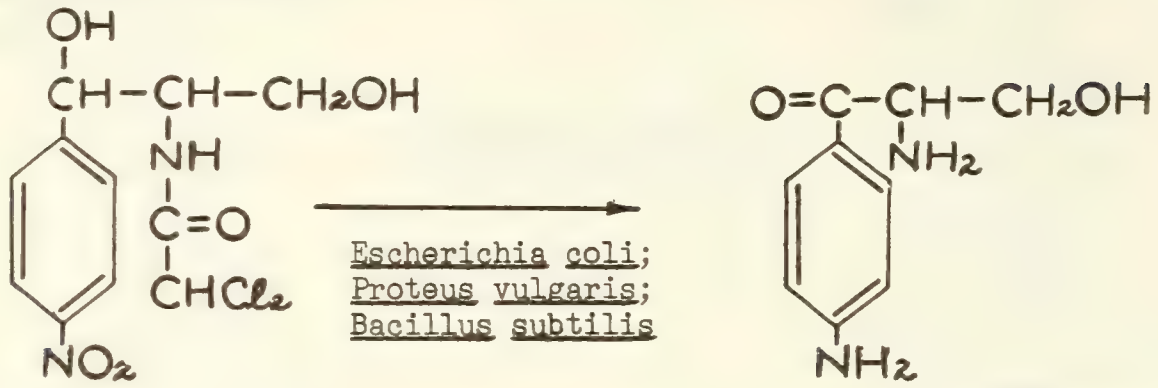


volemitol — D-mannoheptulose (42%)

Smith and Worrel, Arch. Biochem. 28, 232-41 (1950).

C.A. 45, 3031g (1951).

Rx. 98



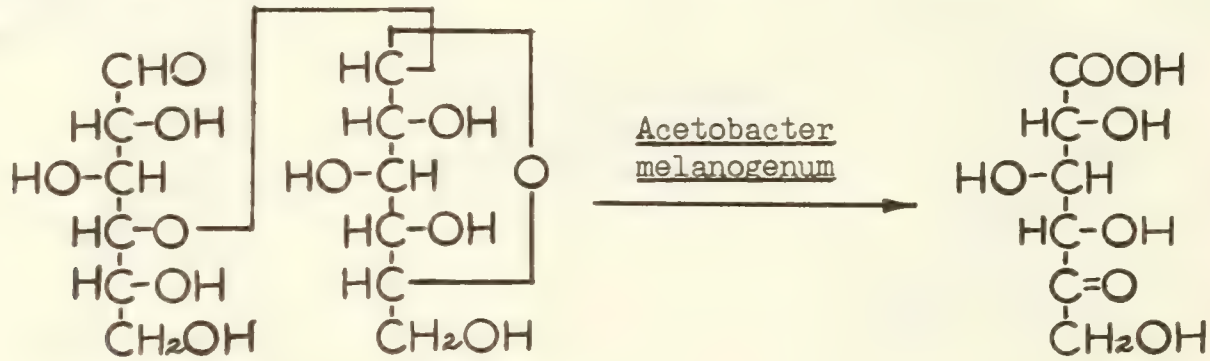
chloramphenicol

α-amino-β-hydroxy-p-aminopropiophenone

Foda and Vaughn, J. Bacteriol. 65, 233-7 (1953).

C.A. 47, 5990d (1953).

Rx. 99



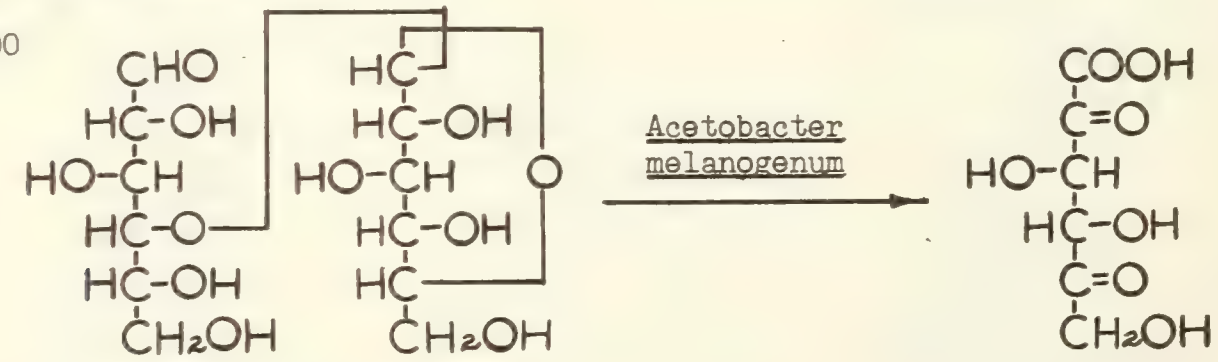
maltose

5-ketogluconic acid

Katznelson and Tanenbaum, J. Bacteriol. 68, 368-72 (1954).

C.A. 48, 13813a (1954).

Rx. 100

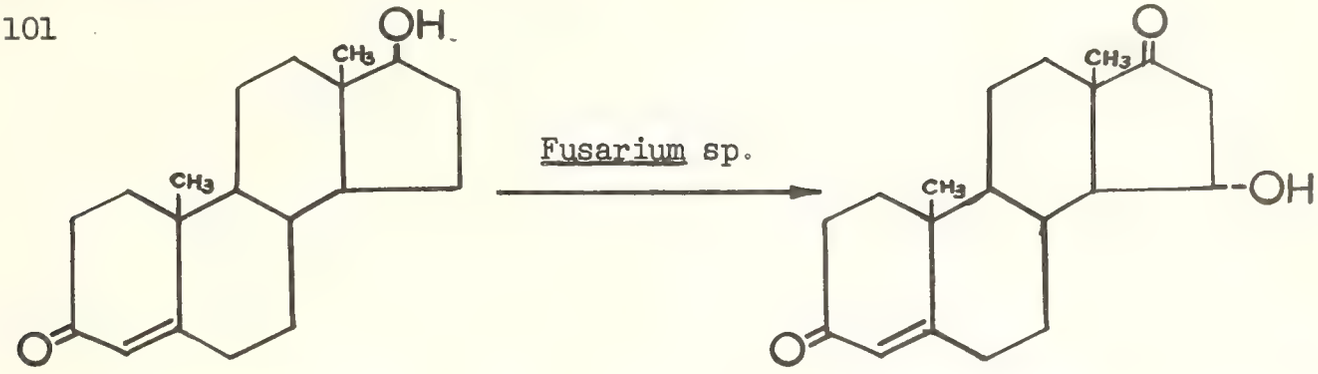


maltose

2,5-diketogluconic acid

Meister et al. in Peterson, Record Chem. Progr. 17, 211-40 (1956).
C.A. 51, 3635c (1957).

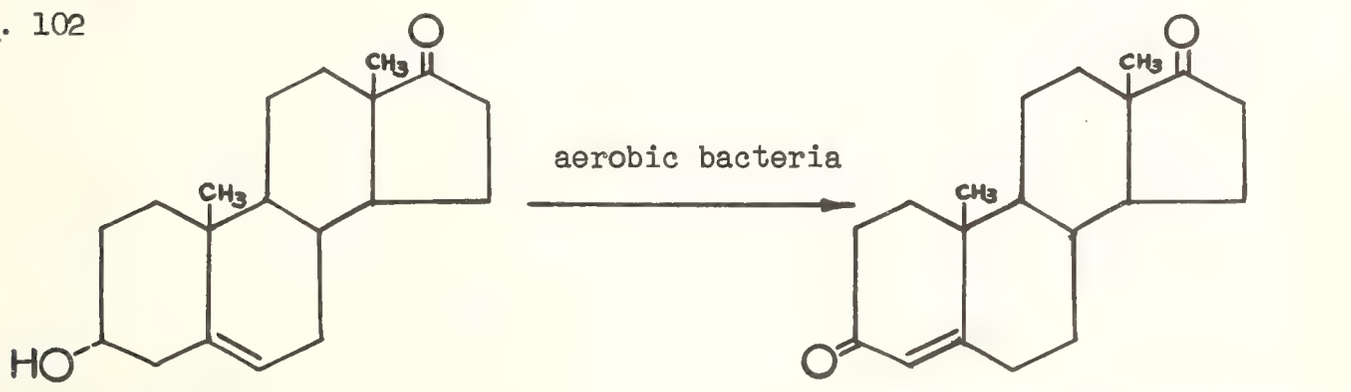
Rx. 101



testosterone — 15 α-hydroxy-4-androstene-3,17-dione

Mamoli and Vercellone, Ber. 71B, 1686-7 (1938).
C.A. 32, 8431[9] (1938).

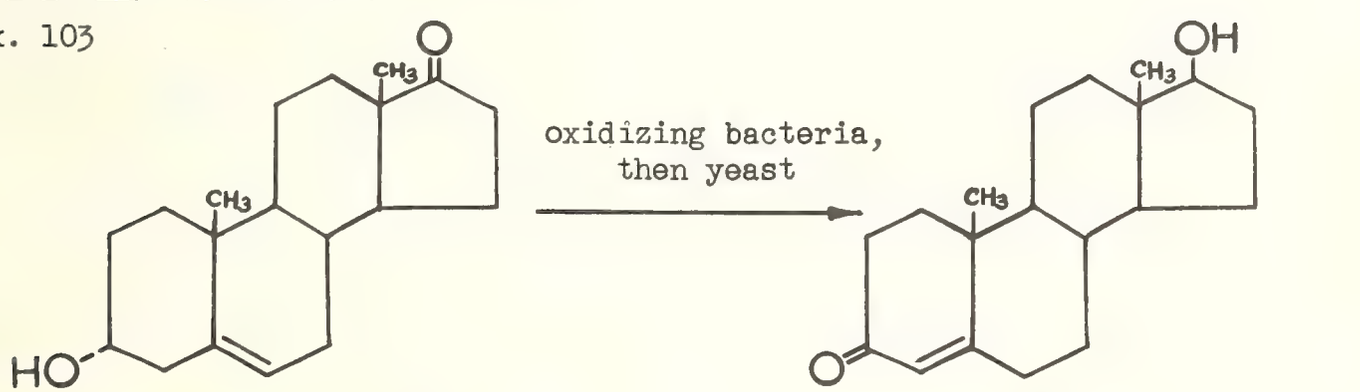
Rx. 102



Δ^5-androstene-3α-ol-17-one (dehydroandrosterone) — Δ^4-androstene-3,17-dione (87%)

Mamoli, Ber. 71B, 2278-80 (1938).
C.A. 33, 1352[8] (1939).

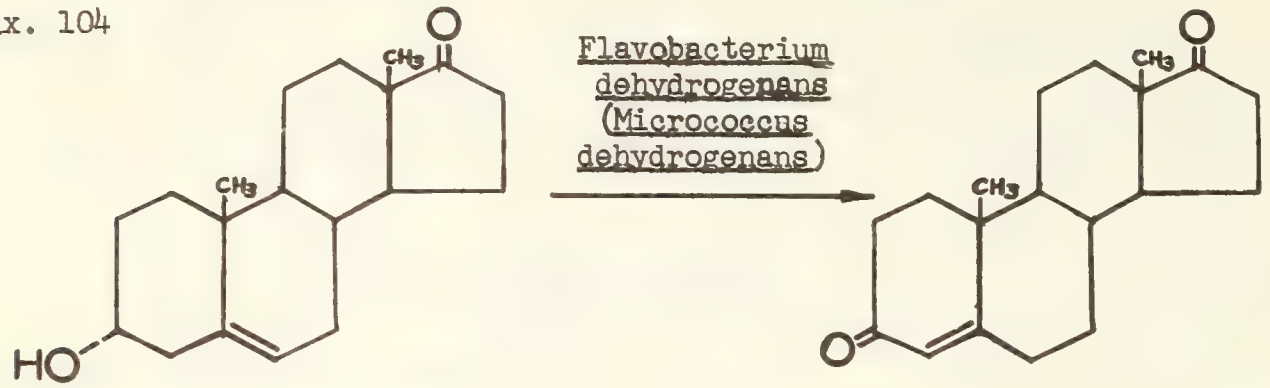
Rx. 103



dehydroandrosterone — testosterone (81%)

Arnaudi, Boll. sez. ital., Soc. intern. microbiol. 11, 208-11 (1939).
C.A. 34, 3301[4] (1940).

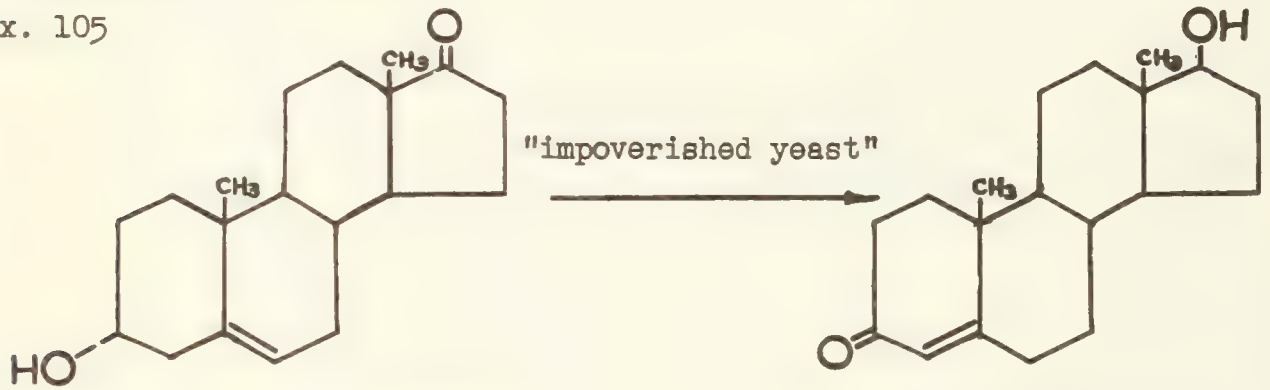
Rx. 104



dehydroandrosterone — Δ^4-androstene-3,17-dione

Koester et al., U. S. 2,236,574 (April 1, 1941).
C.A. 35, P4393[4] (1941).

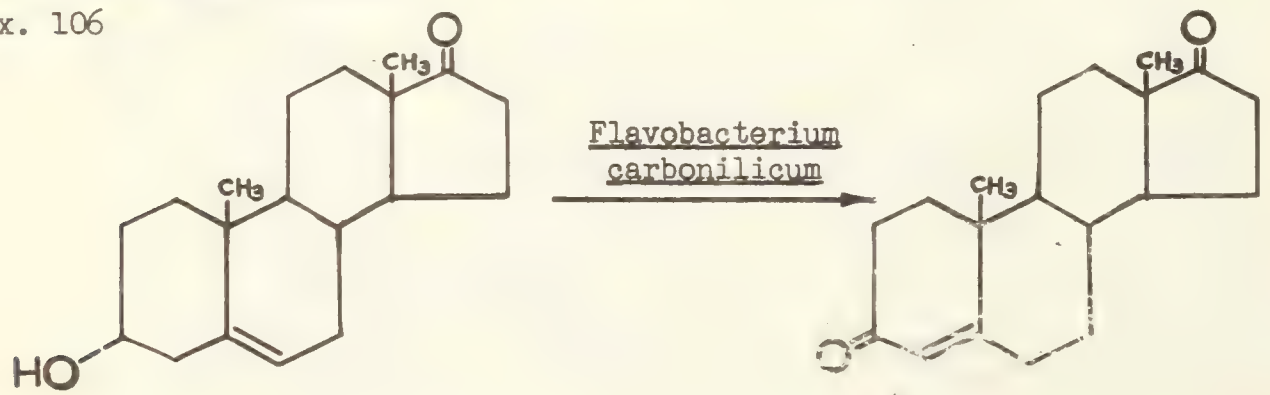
Rx. 105



dehydroandrosterone — testosterone

Molina and Ercoli, Boll. ist. sieroterap. milanese 23, 164-7 (1944).
C.A. 40, 3152[9] (1946).

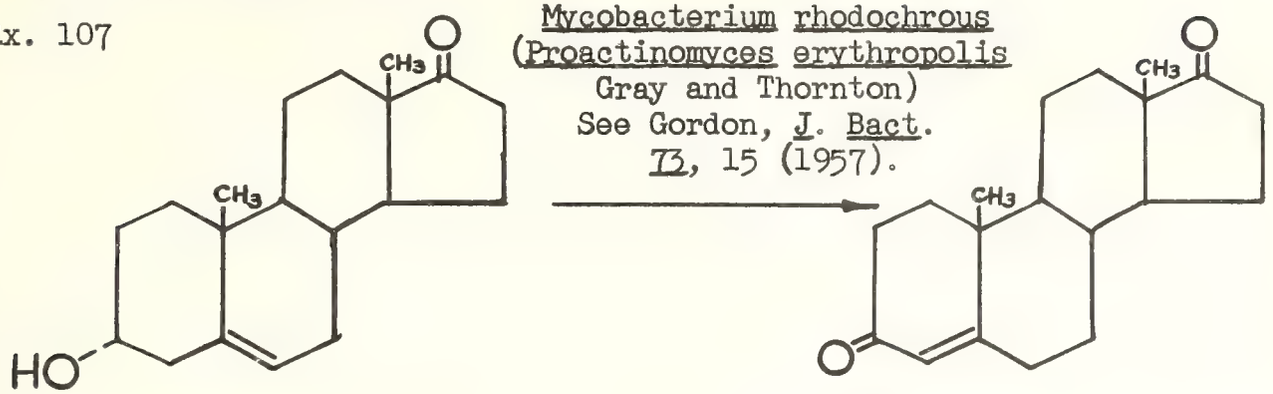
Rx. 106



dehydroandrosterone — Δ^4-androstene-3,17-dione

Turfitt, Biochem. J. 40, 79-81 (1946).
C.A. 40, 4105[8] (1946).

Rx. 107



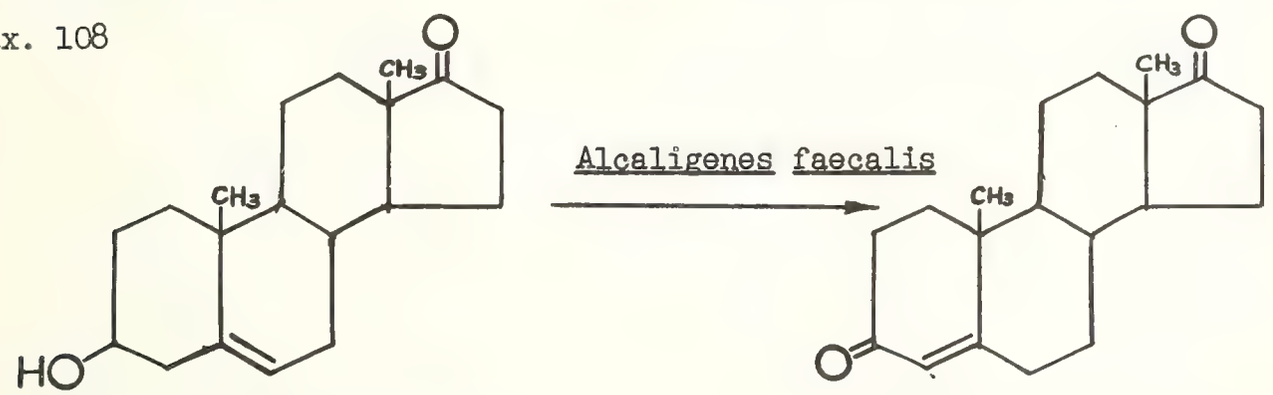
Mycobacterium rhodochrous
(Proactinomyces erythropolis
Gray and Thornton)
See Gordon, J. Bact.
73, 15 (1957).

dehydroandrosterone

Δ^4-androstene-3,17-dione

Hughes and Schmidt, Proc. Soc. Exptl. Biol. Med. 51, 162-3 (1942).
C.A. 37, 660[8] (1943).

Rx. 108



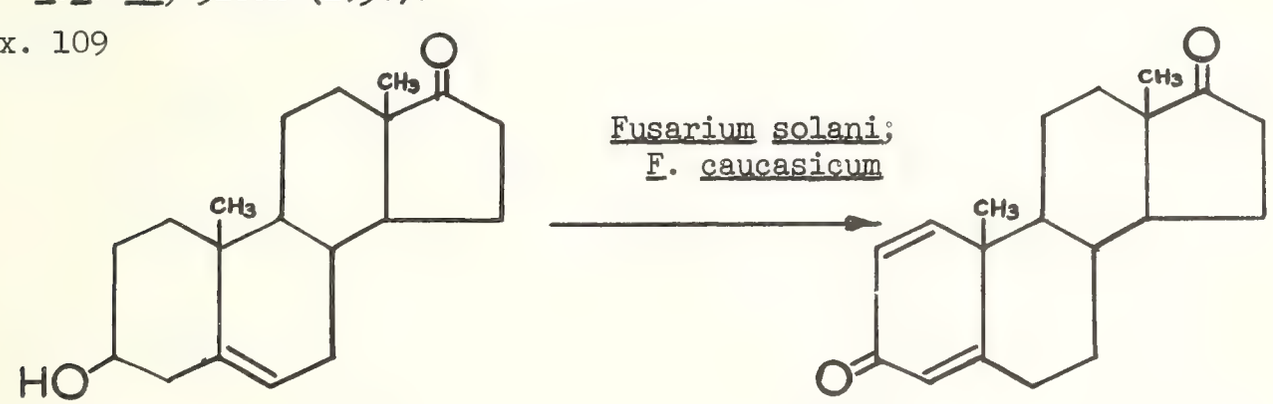
Alcaligenes faecalis

Δ^5-androstene-3β-ol-17-one
(dehydroisoandrosterone)

Δ^4-androstene-3,17-dione
(nearly 100%)

Vischer and Wettstein, Experientia 9, 371-2 (1953).
C.A. 48, 5268h (1954).

Rx. 109



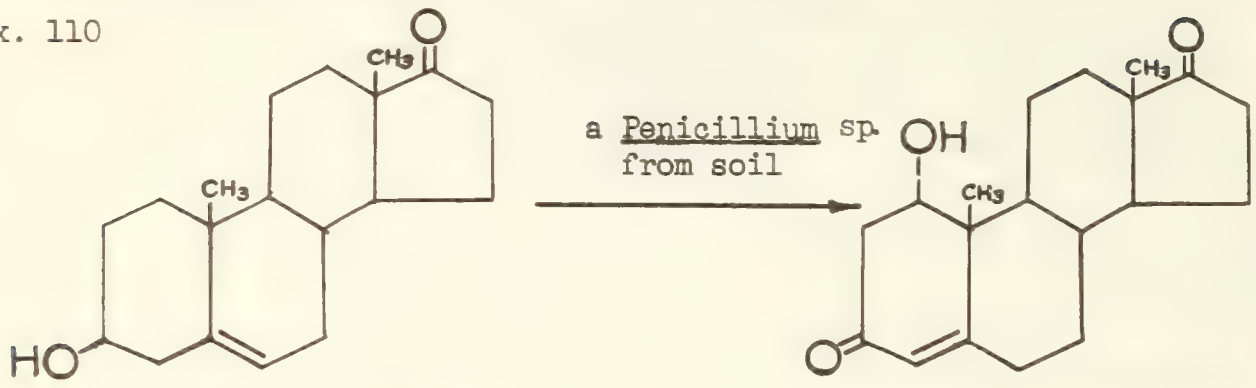
Fusarium solani;
F. caucasicum

dehydroisoandrosterone

$\Delta^{1,4}$-androstadien-3,17-dione

Dodson et al., J. Am. Chem. Soc. 79, 3921 (1957).
C.A. 51, 18113d (1957).

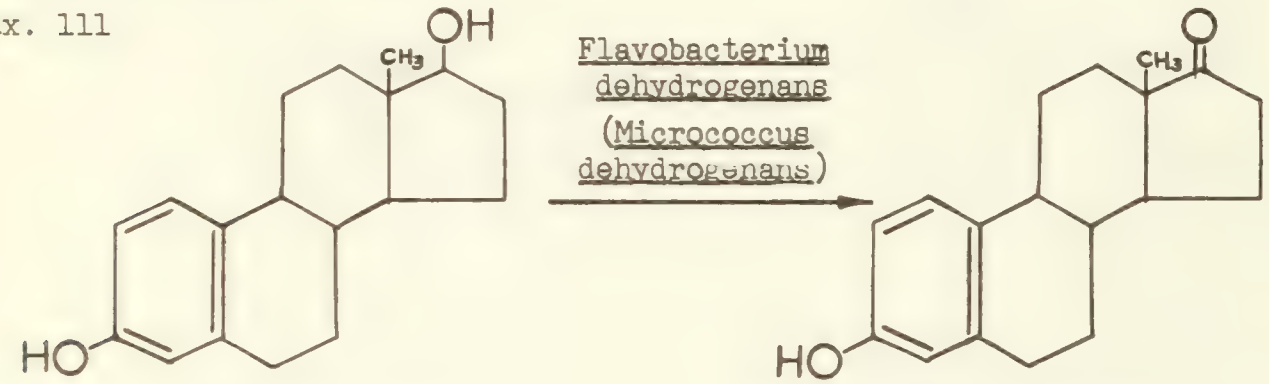
Rx. 110



dehydroisoandrosterone — 1 α-hydroxy-4-androstene-3,17-dione

Ercoli, Biochim. terap. sper. 28, 215-8 (1941).
C.A. 40, 7338[6] (1946).

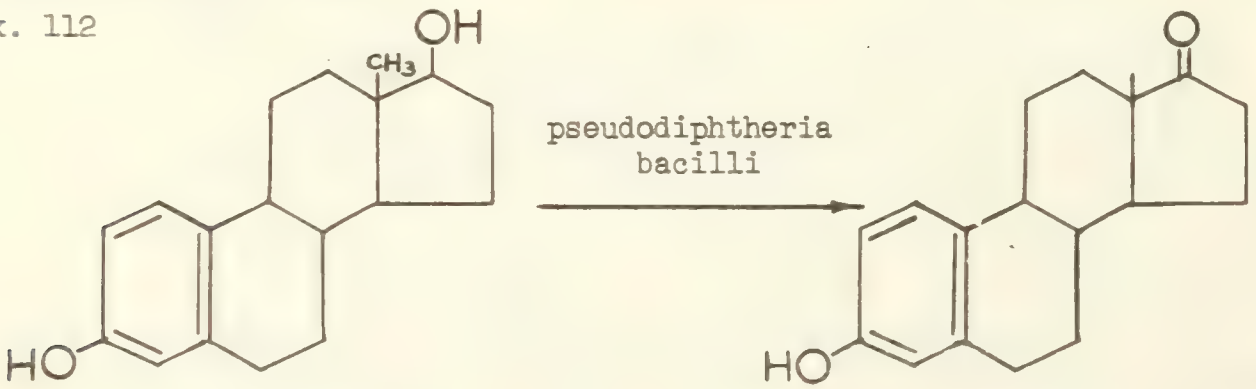
Rx. 111



estradiol — estrone

Zimmermann and May, Zentr. Bakt., Parasitenk. I Abt. 151, 462-6 (1944).
C.A. 40, 4765[3] (1946).

Rx. 112

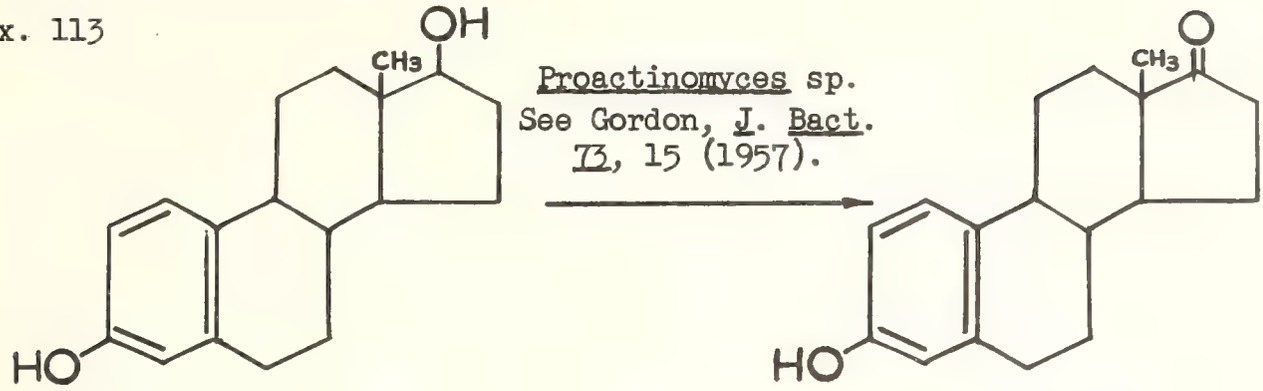


estradiol — estrone

Turfitt, Biochem. J. 42, 376-82 (1948).

C.A. 42, 6406e (1948).

Rx. 113

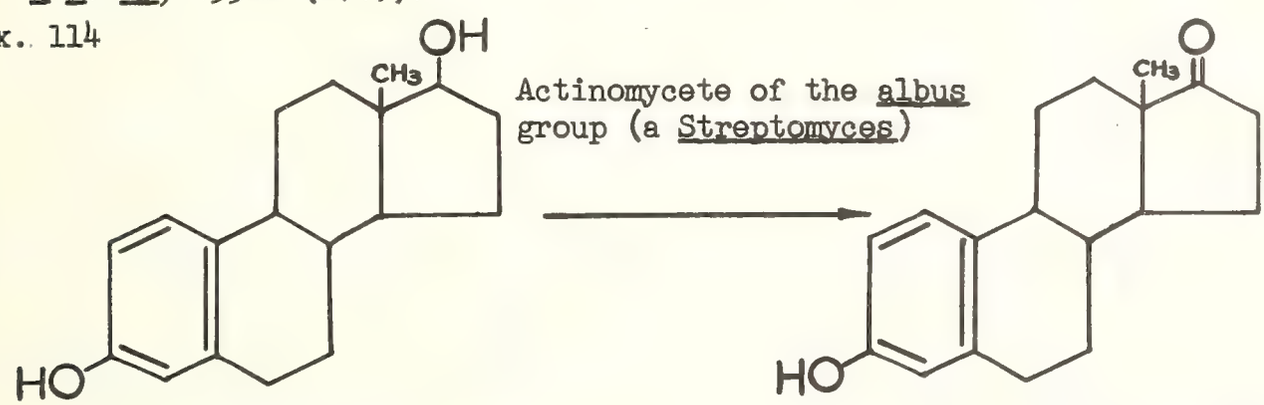


estradiol — estrone

Welsch and Heusghem, Compt. rend. soc. biol. 142, 1074-6 (1948).

C.A. 43, 4331b (1949).

Rx. 114

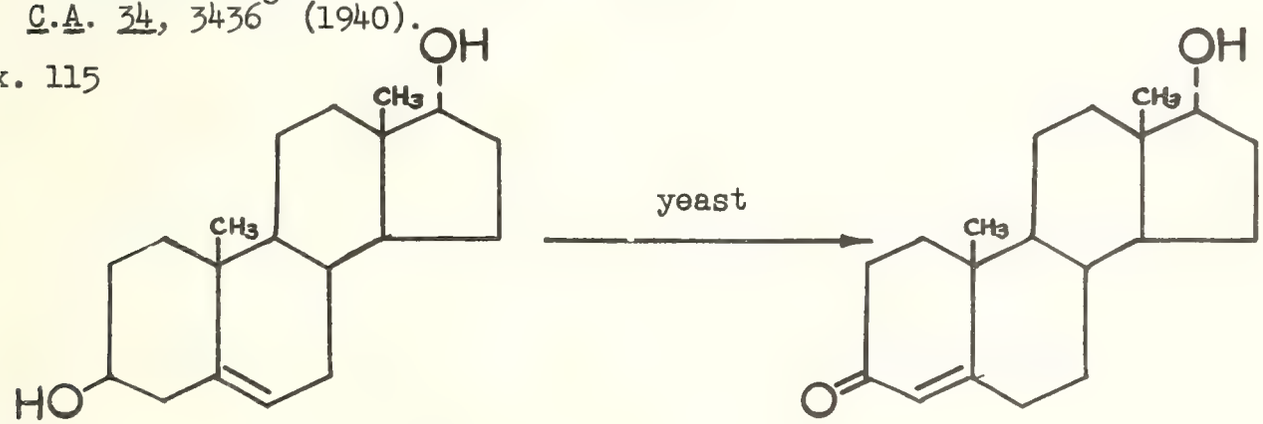


estradiol — estrone (almost 100%)

Mamoli, U. S. 2,186,906 (Jan. 9, 1940).

C.A. 34, 3436[8] (1940).

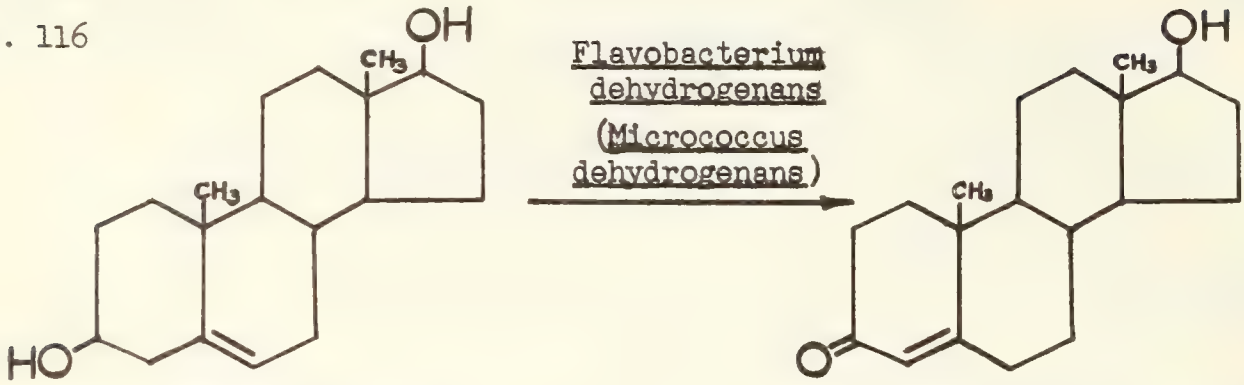
Rx. 115



Δ^5-androstene-3β, 17α-diol — epitestosterone (Δ^4-androstene-17α-ol-3-one)

Ercoli, Z. physiol. Chem. 270, 266-70 (1941).
C.A. 37, 153[2] (1943).

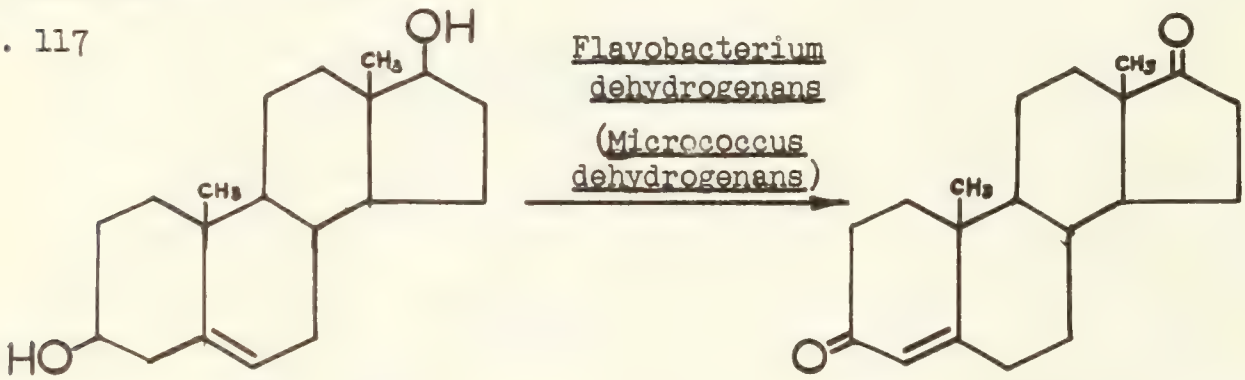
Rx. 116



Δ^5-androstenediol — testosterone (64%)

Ercoli, Z. physiol. Chem. 270, 266-70 (1941).
C.A. 37, 153[2] (1943).

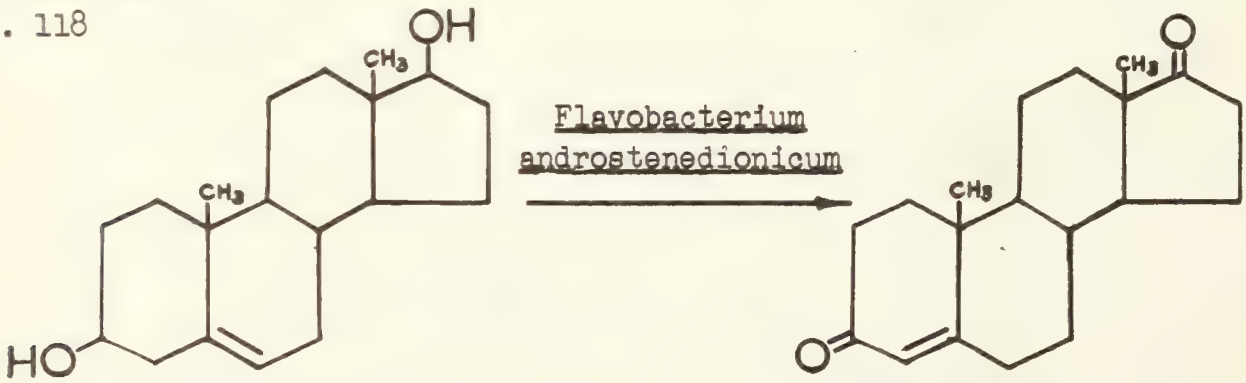
Rx. 117



Δ^5-androstenediol — Δ^4-androstene-3,17-dione (4%)

Ercoli and Molina, Boll. ist. sieroterap. milanese 23, 158-63 (1944).
C.A. 40, 3152[8] (1946).

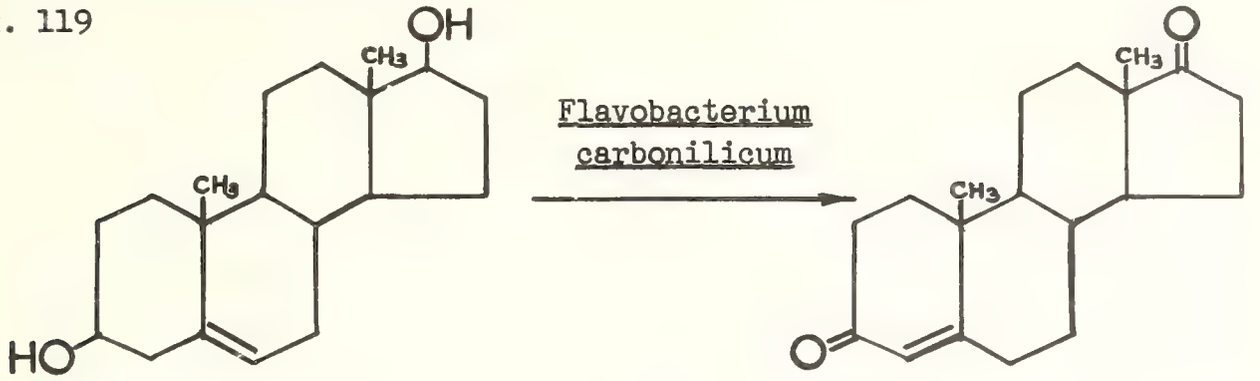
Rx. 118



Δ^5-androstenediol — Δ^4-androstene-3,17-dione

Molina and Ercoli, Boll. ist. sieroterap. milanese 23, 164-7 (1944). C.A. 40, 3152[9] (1946).

Rx. 119

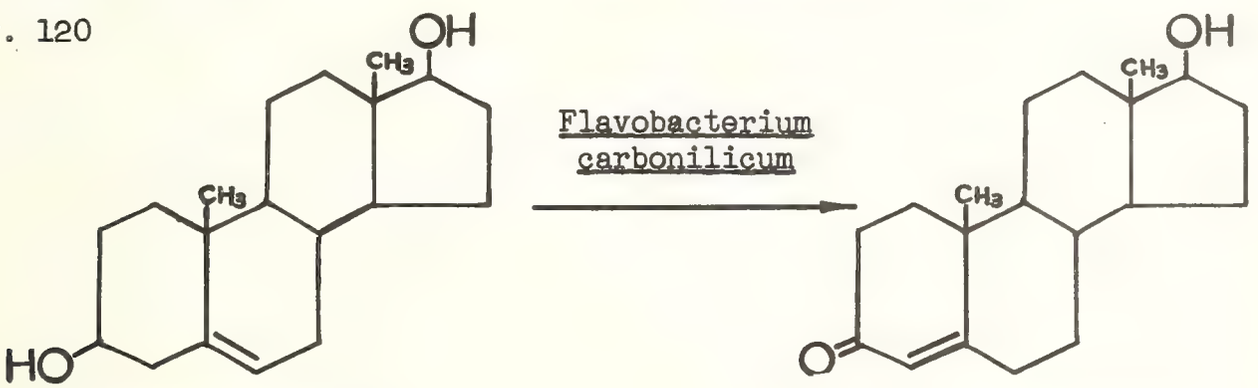


Δ^5-androstenediol

Δ^4-androstene-3,17-dione

Molina and Ercoli, Boll. ist. sieroterap. milanese 23, 164-7 (1944). C.A. 40, 3152[9] (1946).

Rx. 120

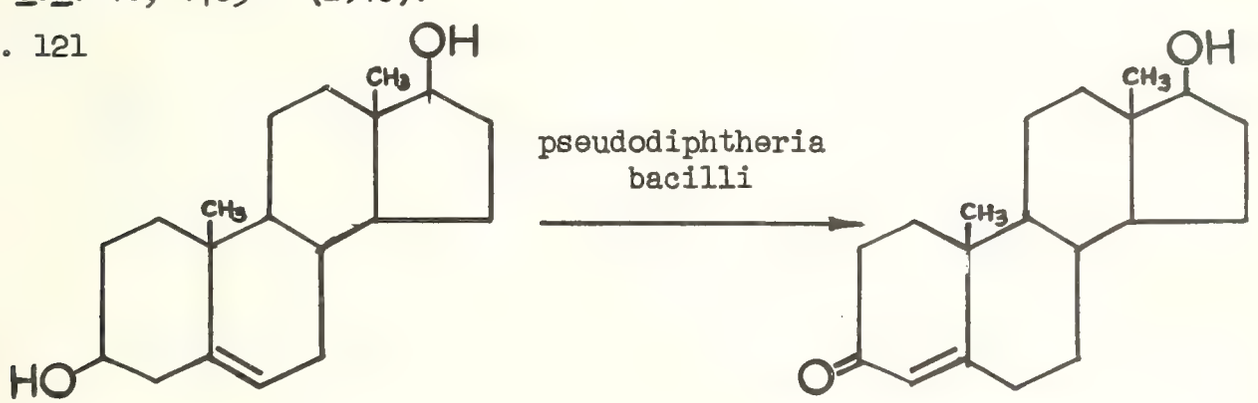


Δ^5-androstenediol

testosterone

Zimmermann and May, Zentr. Bakt. Parasitenk. I Abt. 151, 462-6 (1944). C.A. 40, 4765[3] (1946).

Rx. 121



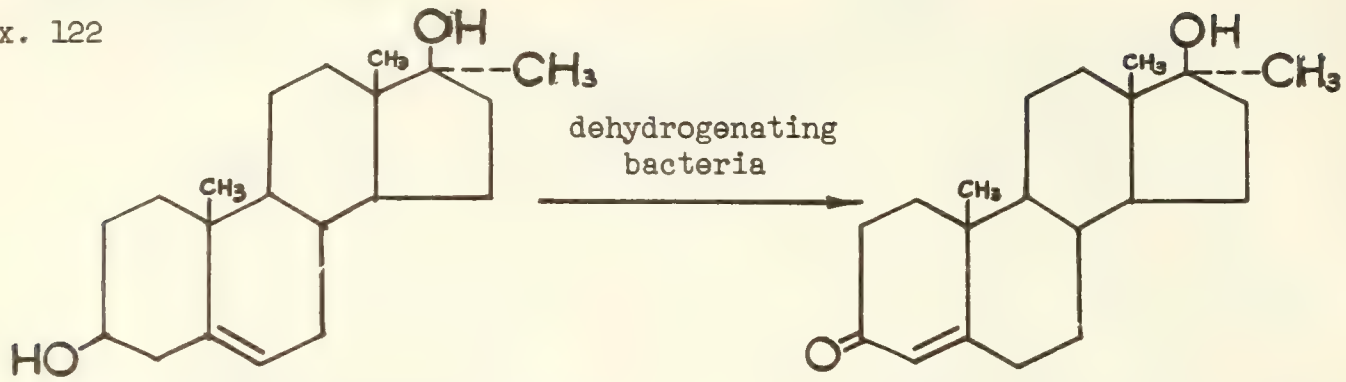
Δ^5-androstenediol

testosterone

Mamoli, Gazz. chim. ital. 69, 237-40 (1939).

C.A. 33, 9311[2] (1939).

Rx. 122



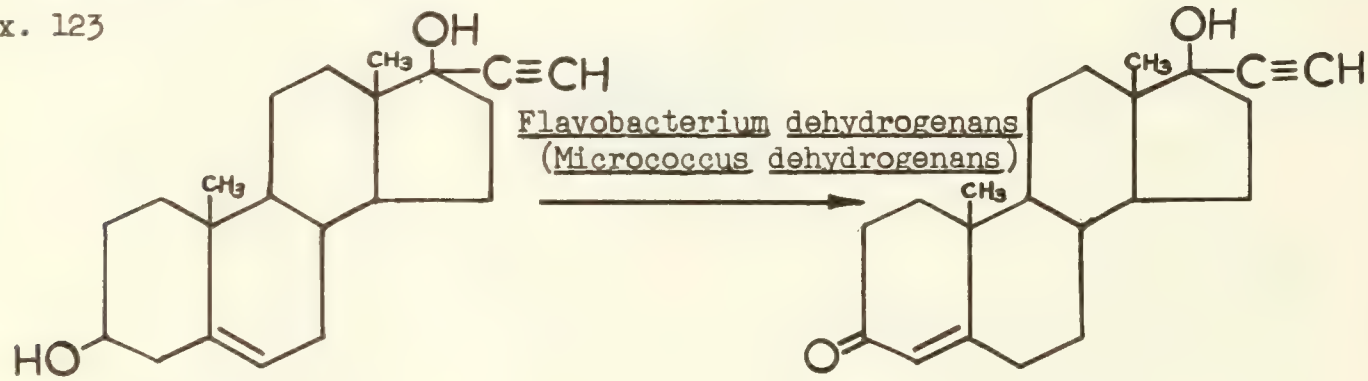
17-methyl-Δ^5-androstene-3,17-diol

17-methyltestosterone (75%)
(See Heilbron, Vol. III, p. 510)

Ercoli, Biochim. terap. sper. 28, 125-30 (1941).

C.A. 38, 2987[9] (1944).

Rx. 123



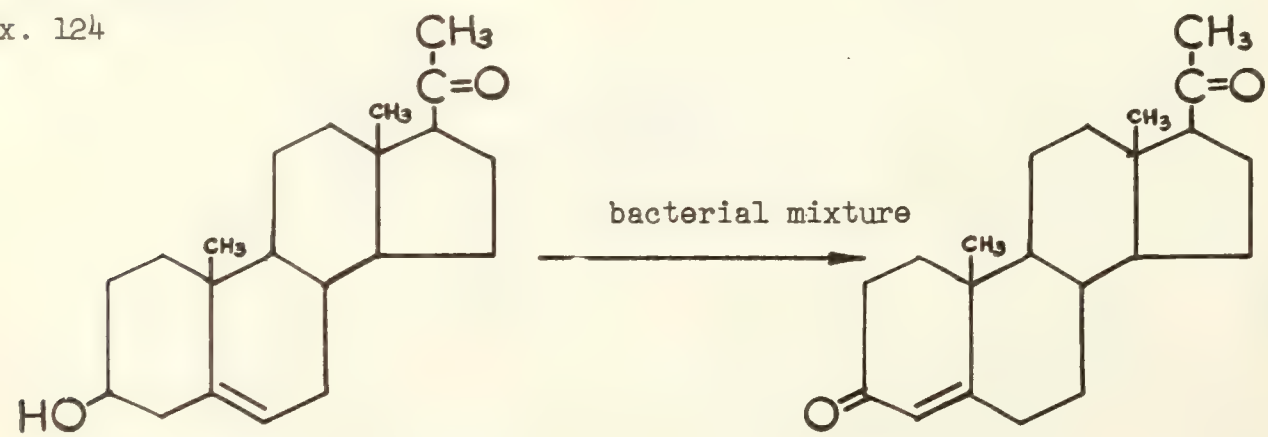
17-ethinylandrostene-3,17-diol

pregneninolone
(17-ethinyltestosterone)

Mamoli, Ber. 71B, 2701-3 (1938).

C.A. 33, 2157[4] (1939).

Rx. 124



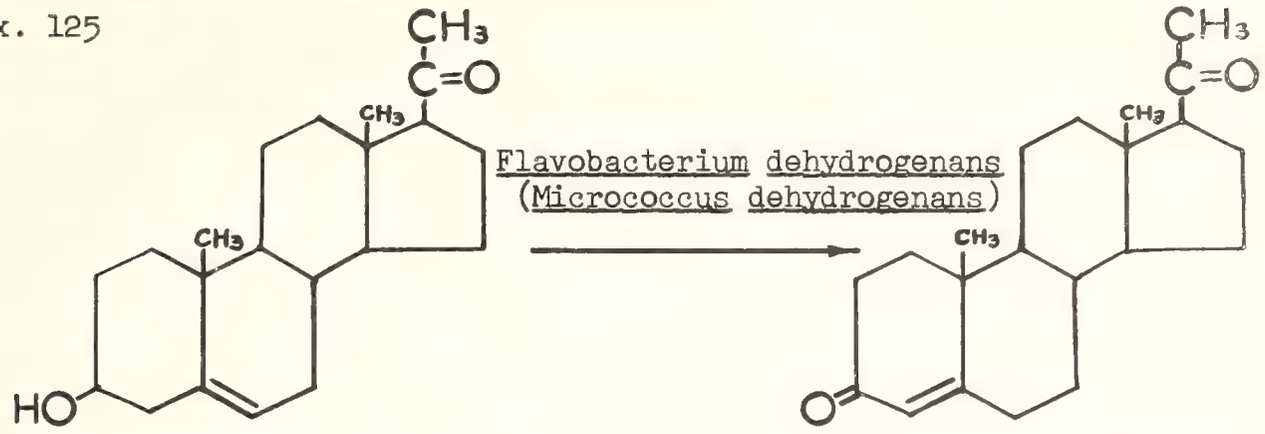
Δ^5-pregnene-3β-ol-20-one
(Δ^5-pregnenolone)

progesterone

Ercoli, Boll. sci. facoltà chim. ind. Bologna, 279-82 (1940).

C.A. 38, 1540[8] (1944).

Rx. 125



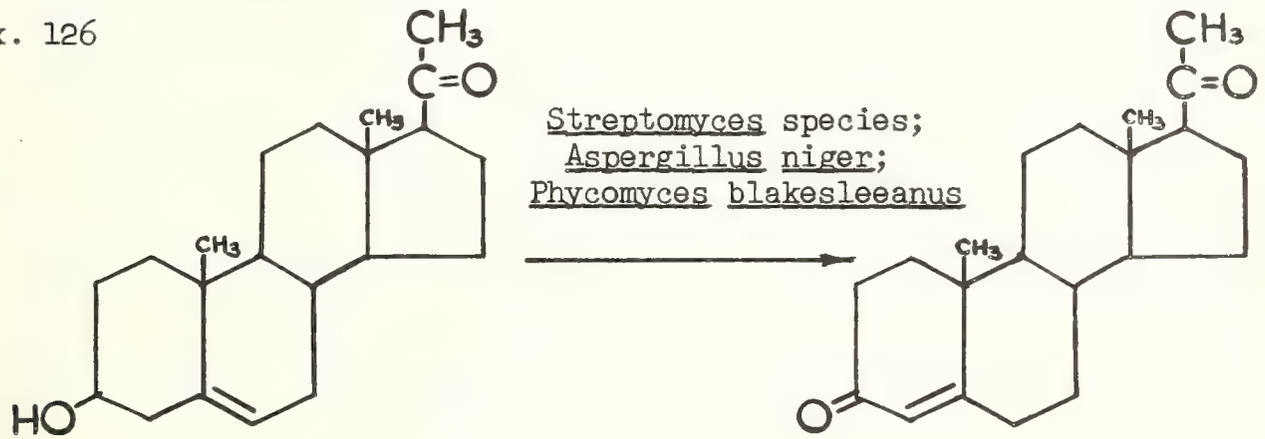
Δ^5-pregnene-3β-ol-20-one (Δ^5-pregnenolone)

progesterone (82%)

Perlman, Science 115, 529 (1952).

C.A. 46, 7620a (1952).

Rx. 126



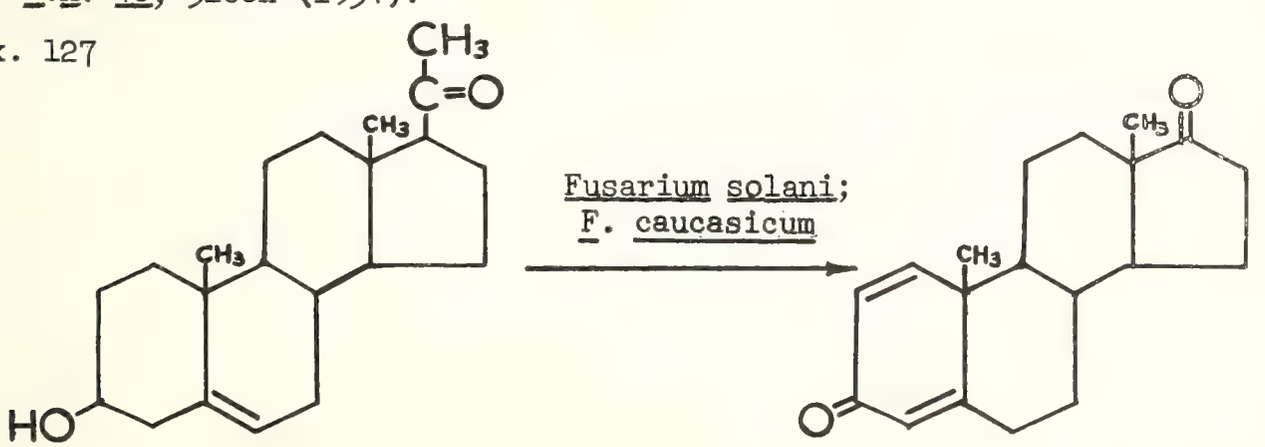
Δ^5-pregnene-3β-ol-20-one

progesterone

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 127



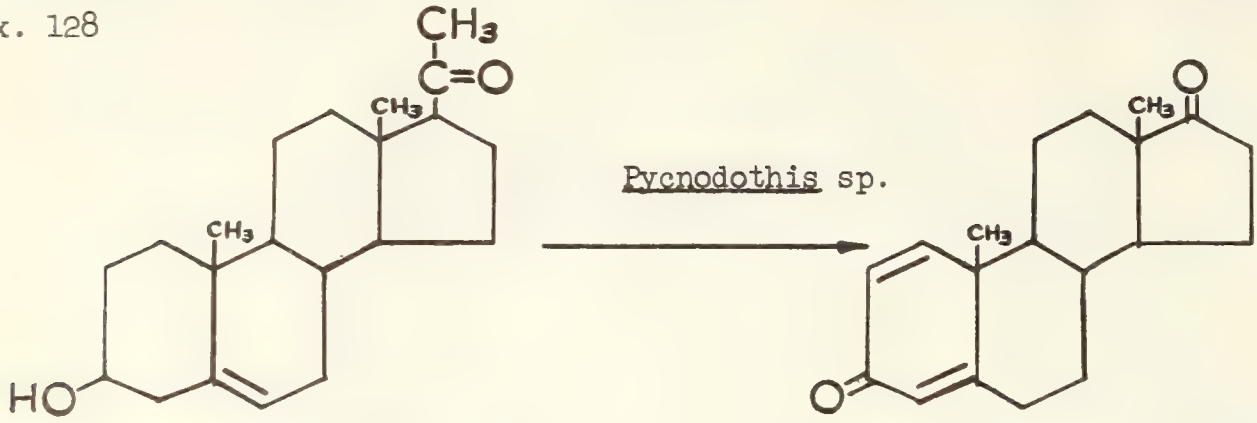
Δ^5-pregnene-3β-ol-20-one

$\Delta^{1,4}$-androstadiene-3,17-dione

Kita and Shull, in Shull, Trans. N. Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 128



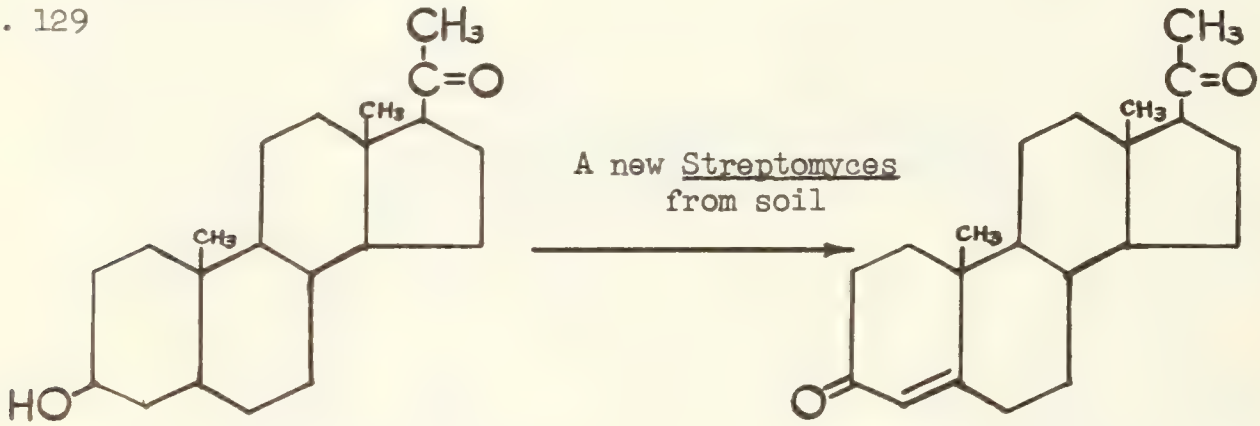
Δ^{5}-pregnene-3β-ol-20-one

$\Delta^{1,4}$-androstadiene-3,17-dione

Perlman et al., J. Bacteriol. 69, 347-52 (1955).

C.A. 49, 8381g (1955).

Rx. 129



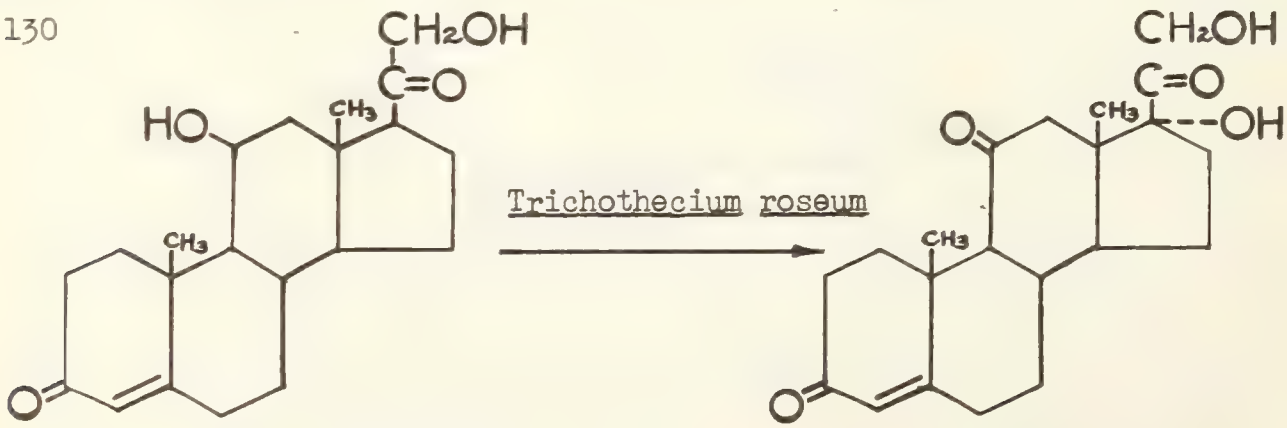
pregnane-3β-ol-20-one

progesterone

Meystre et al., Helv. Chim. Acta 37, 1548-53 (1954).

C.A. 48, 13797d (1954).

Rx. 130



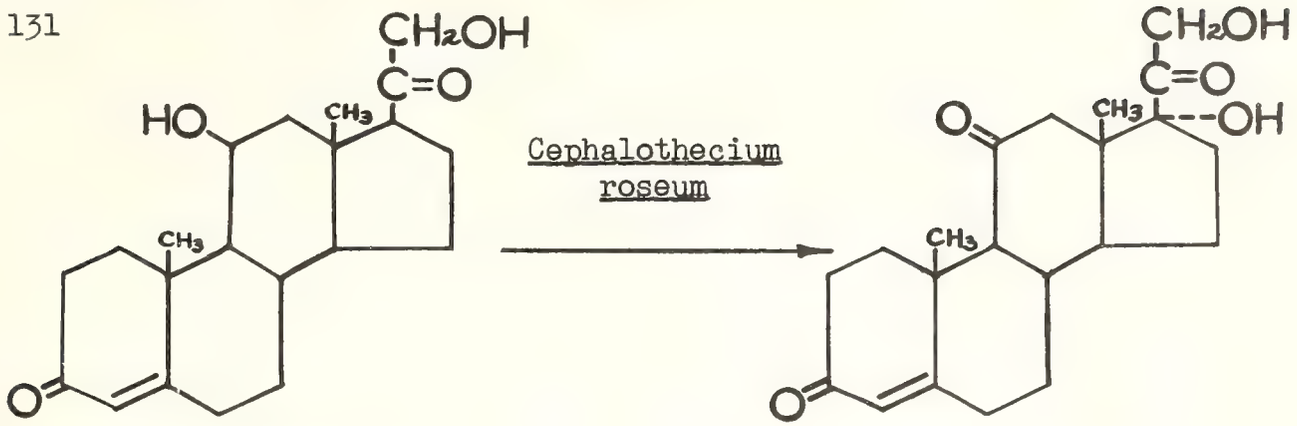
corticosterone

cortisone

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 131

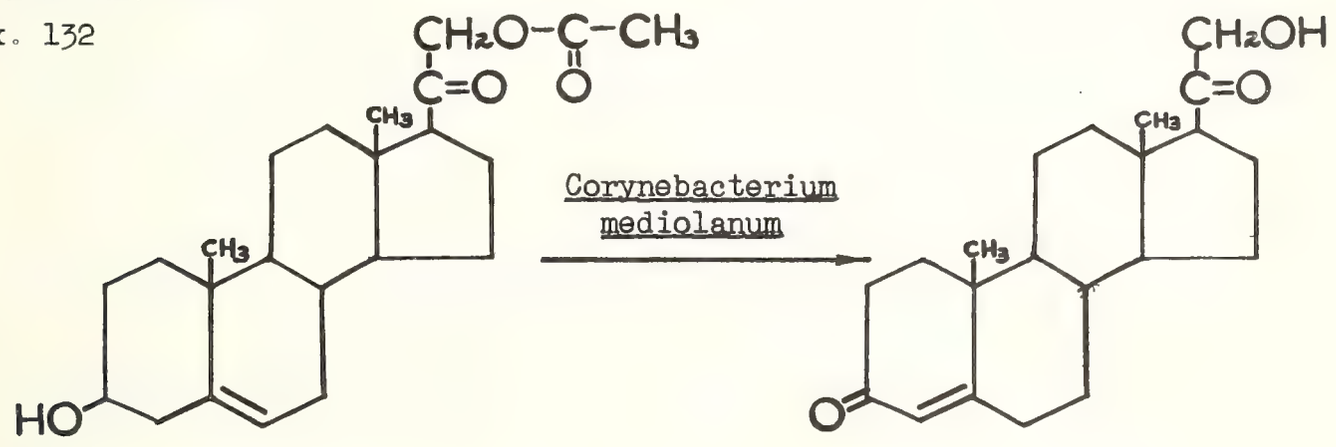


corticosterone — cortisone

Mamoli, Ber. 72B, 1863-5 (1939).

C.A. 34, 773[8] (1940).

Rx. 132

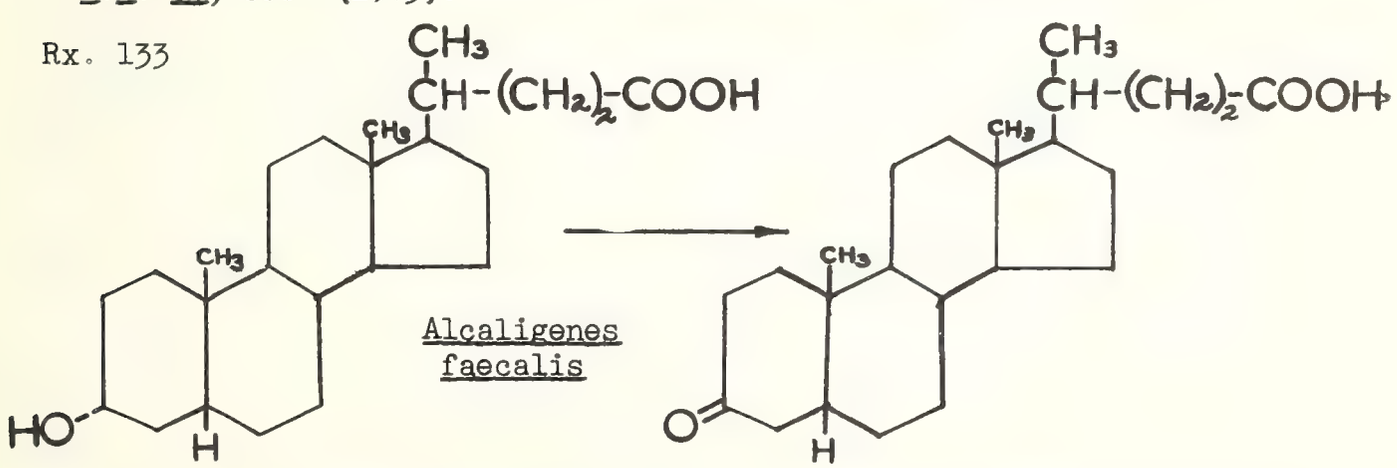


21-acetoxy-Δ^5-pregnene-3β-ol-20-one — 11-desoxycorticosterone (cortexone) (34%)

Hughes and Schmidt, Proc. Soc. Exptl. Biol. Med. 51, 162-3 (1942).

C.A. 37, 660[8] (1943).

Rx. 133

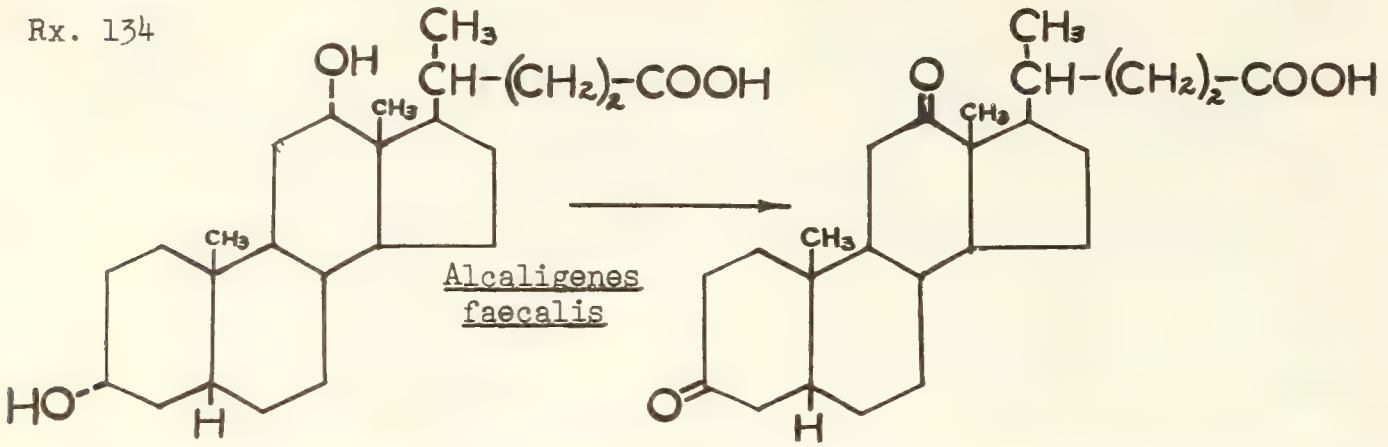


lithocholic acid — 3-ketocholanic acid (25%)

Hughes and Schmidt, Proc. Soc. Exptl. Biol. Med. 51, 162-3 (1942).

C.A. 37, 660[8] (1943).

Rx. 134

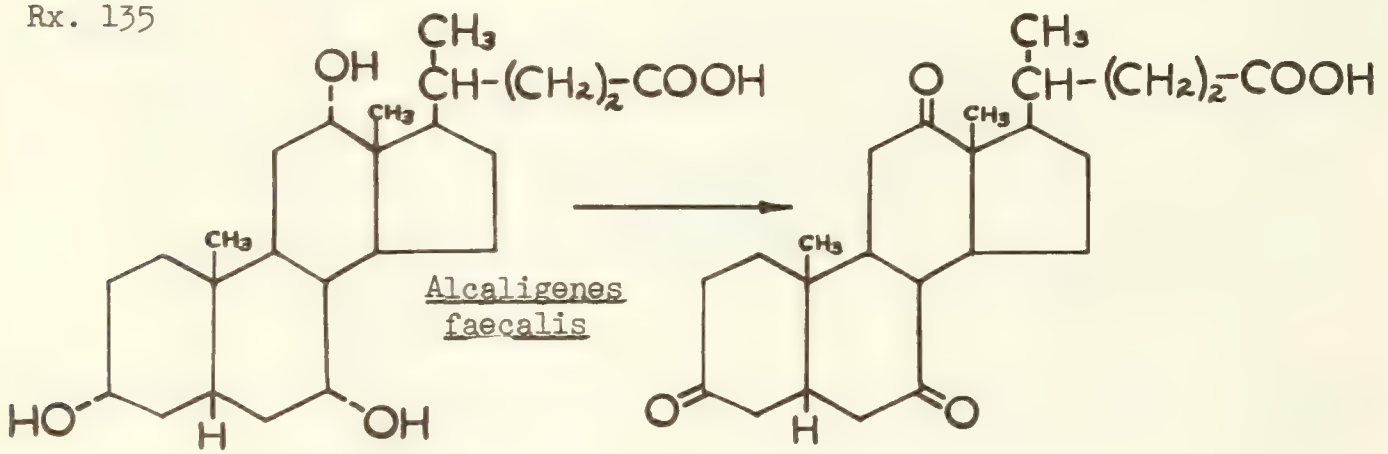


desoxycholic acid — 3,12-diketocholanic acid (nearly 100%)

Schmidt et al., J. Biol. Chem. 145, 229-36 (1942).

C.A. 36, 7060[6] (1942).

Rx. 135

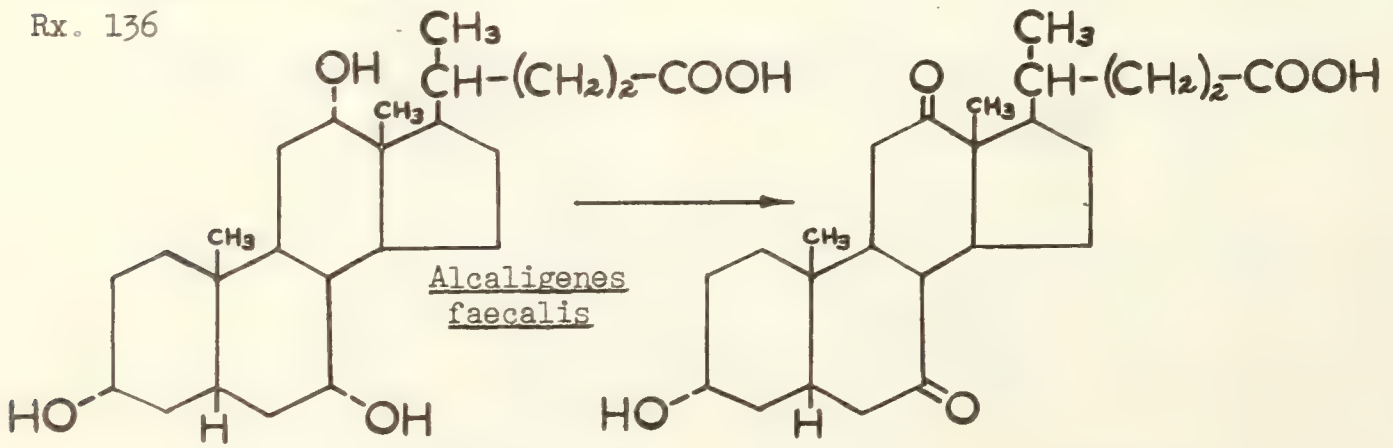


cholic acid — 3,7,12-triketocholanic acid (83%)

Hoehn et al., J. Biol. Chem. 152, 59-66 (1944).

C.A. 38, 1763[9] (1944).

Rx. 136

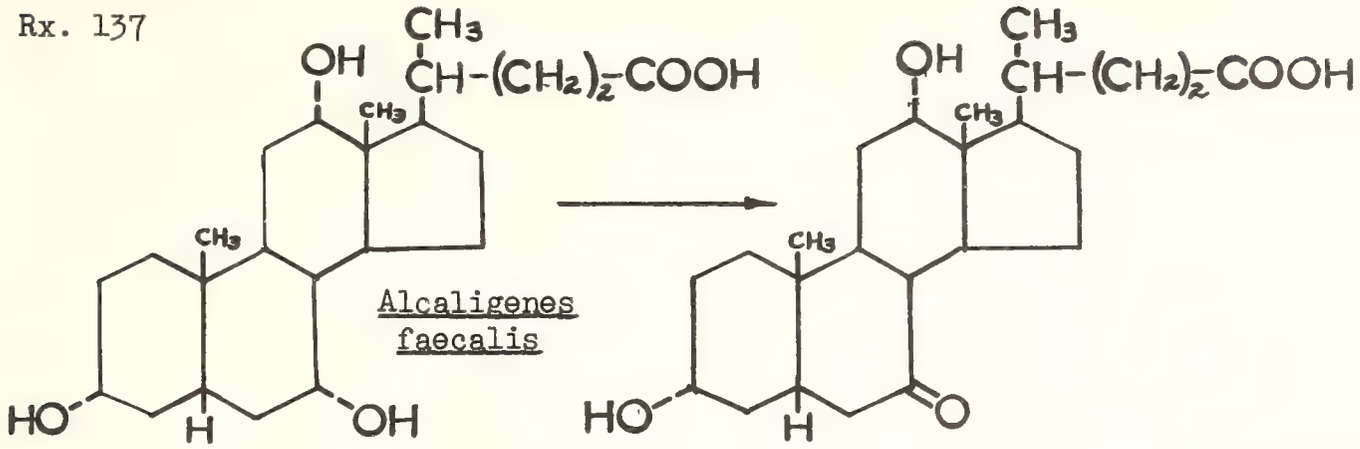


cholic acid — 3-hydroxy-7,12-diketocholanic acid

Hoehn et al., J. Biol. Chem. 152, 59-66 (1944).

C.A. 38, 1763[9] (1944).

Rx. 137

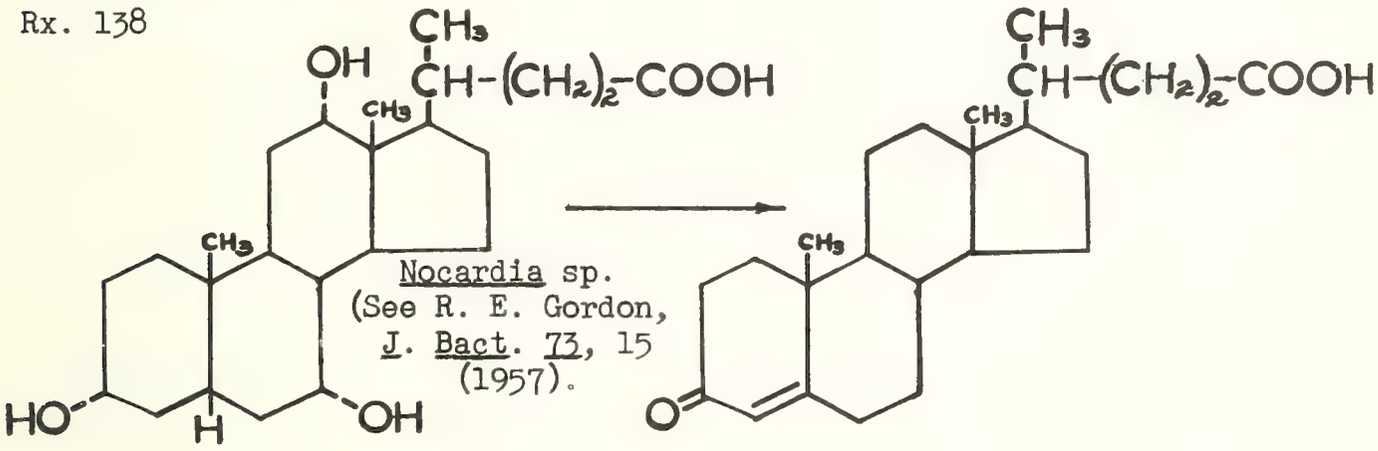


cholic acid — 3,12-dihydroxy-7-ketocholanic acid

Halperin et al., Arch. Biochem. Biophys. 52, 5-17 (1954).

C.A. 48, 13817i (1954).

Rx. 138



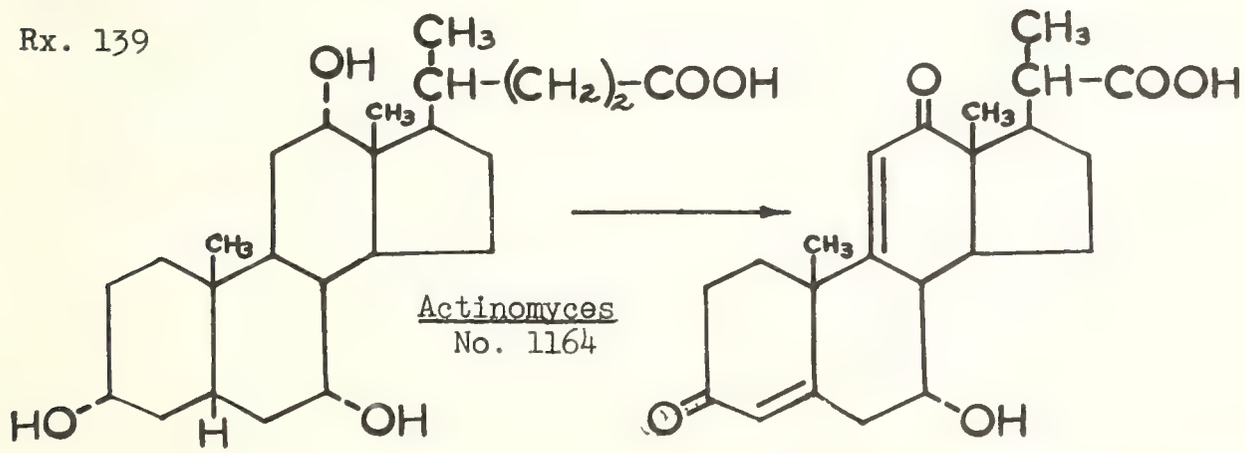
cholic acid — probably a derivative of 3-keto-Δ^4-cholenic acid

---

Hayakawa, Proc. Japan Acad. 30, 133-8 (1954).

C.A. 50, 388c (1956)

Rx. 139

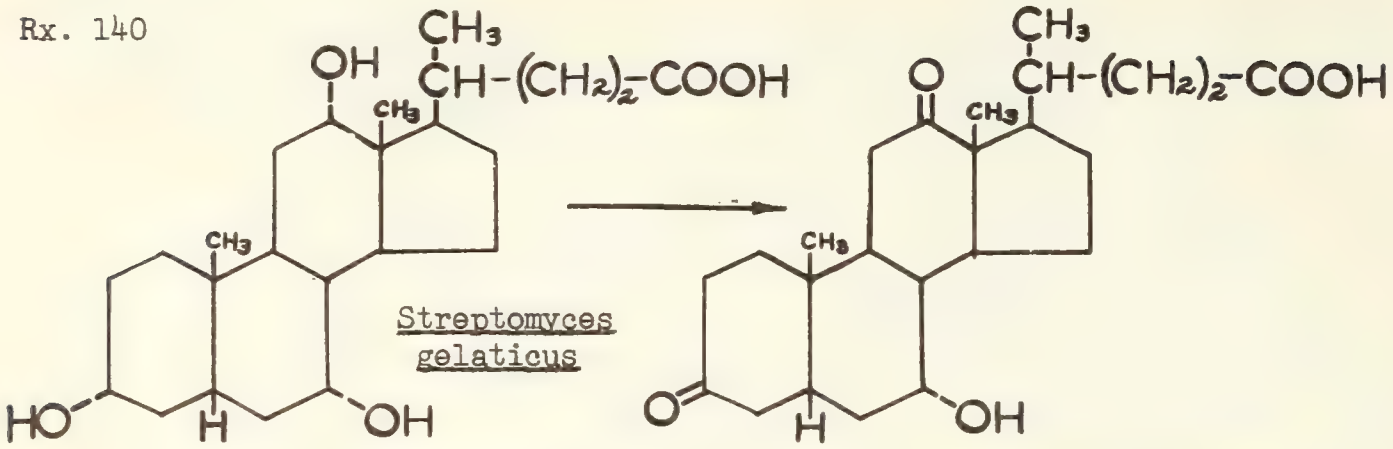


cholic acid — $\Delta^{4,9(11)}$-7-hydroxy-3,12-diketo-bisnorcholadienic acid (6.7%)

Hayakawa et al., Proc. Japan Acad. 32, 519-22 (1956).

C.A. 51, 2111f (1957).

Rx. 140



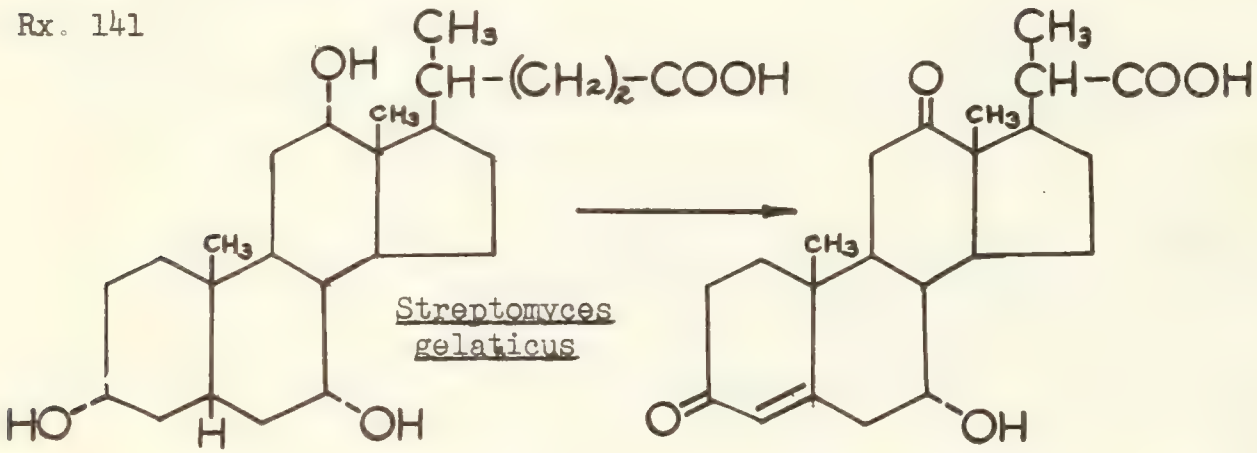
cholic acid

7α-hydroxy-3,12-diketo-cholanic acid (6.7%)

Hayakawa et al., J. Biochem. (Japan) 43, 723-30 (1956).

C.A. 51, 2111d (1957).

Rx. 141



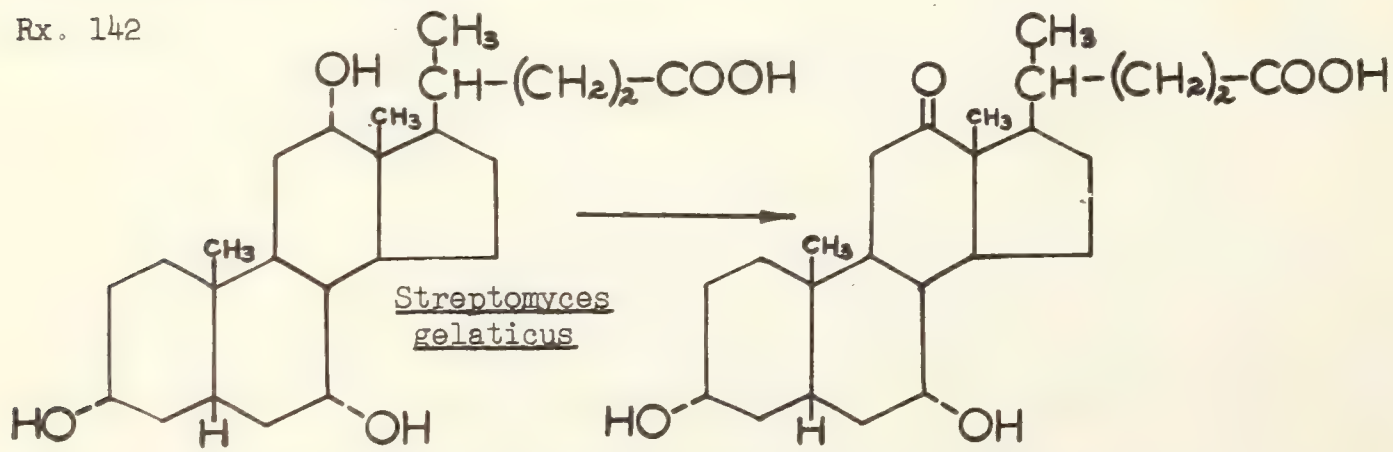
cholic acid

7α-hydroxy-3,12-diketo-Δ^4-bisnorcholenic acid

Hayakawa et al., Proc. Japan Acad. 32, 519-22 (1956).

C.A. 51, 2111f (1957).

Rx. 142



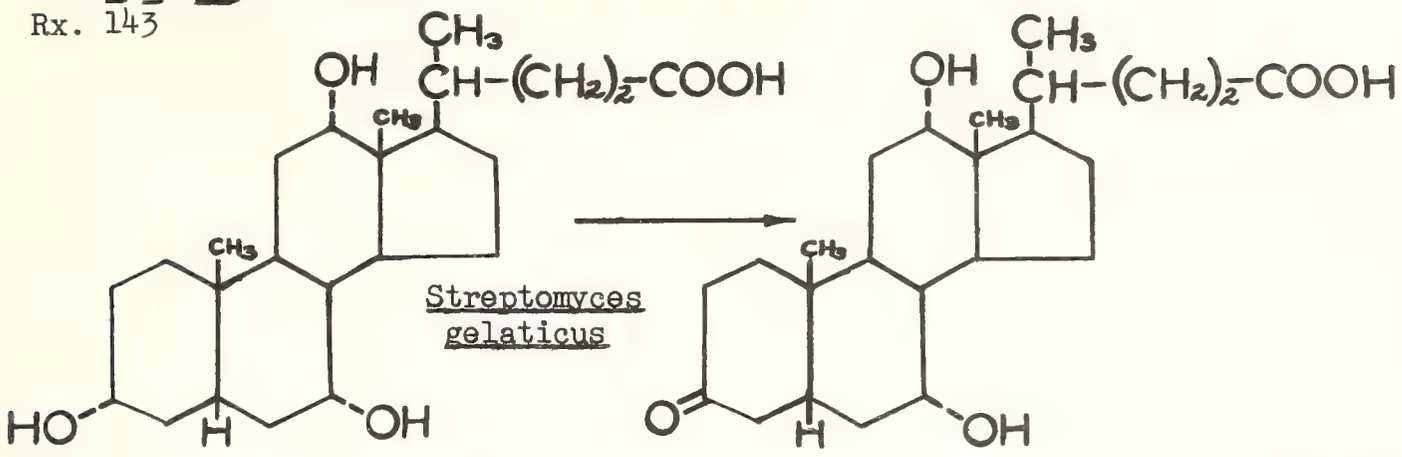
cholic acid

3α,7α-dihydroxy-12-ketocholanic acid

Hayakawa et al., Proc. Japan Acad. 32, 519-22 (1956).

C.A. 51, 2111f (1957).

Rx. 143

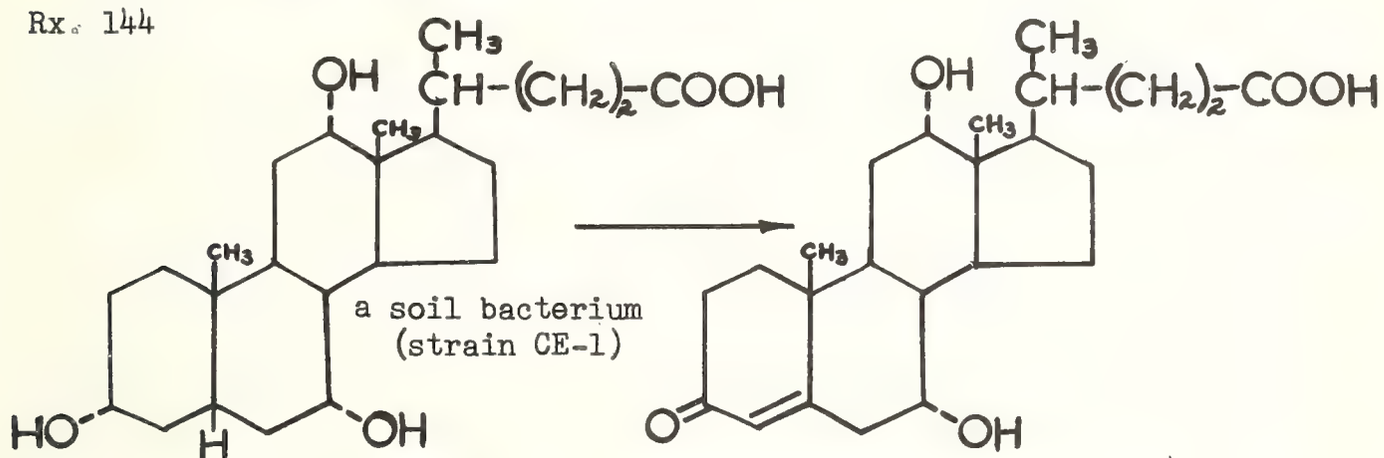


cholic acid — 7α,12α-dihydroxy-3-ketocholanic acid

Eguchi, J. Biochem. (Japan) 44, 81-5 (1957).

C.A. 51, 8872g (1957).

Rx. 144

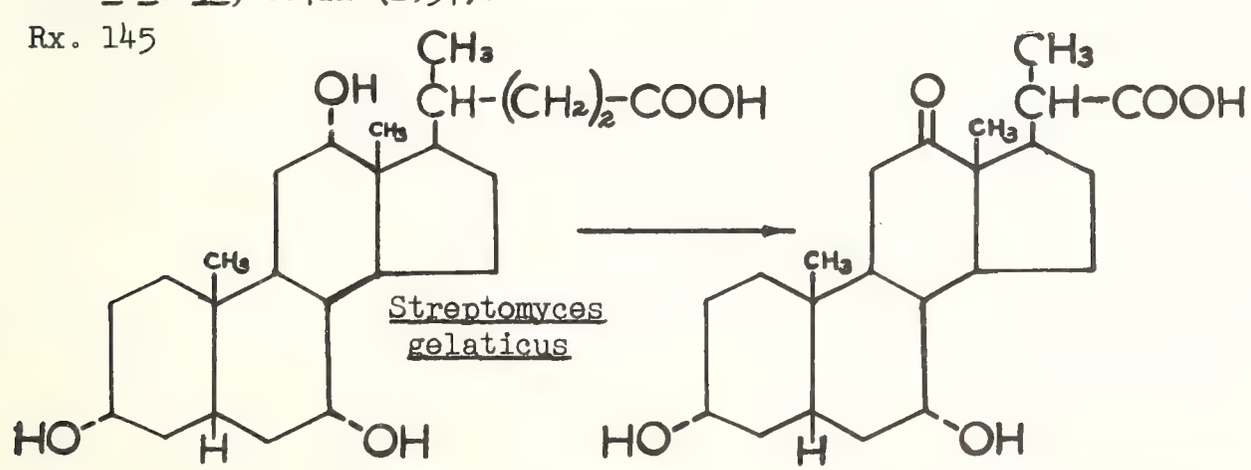


cholic acid — 7α,12α-dihydroxy-3-keto-Δ^4-cholenic acid

Hayakawa et al., J. Biochem. (Japan) 44, 109-13 (1957).

C.A. 51, 8872h (1957).

Rx. 145

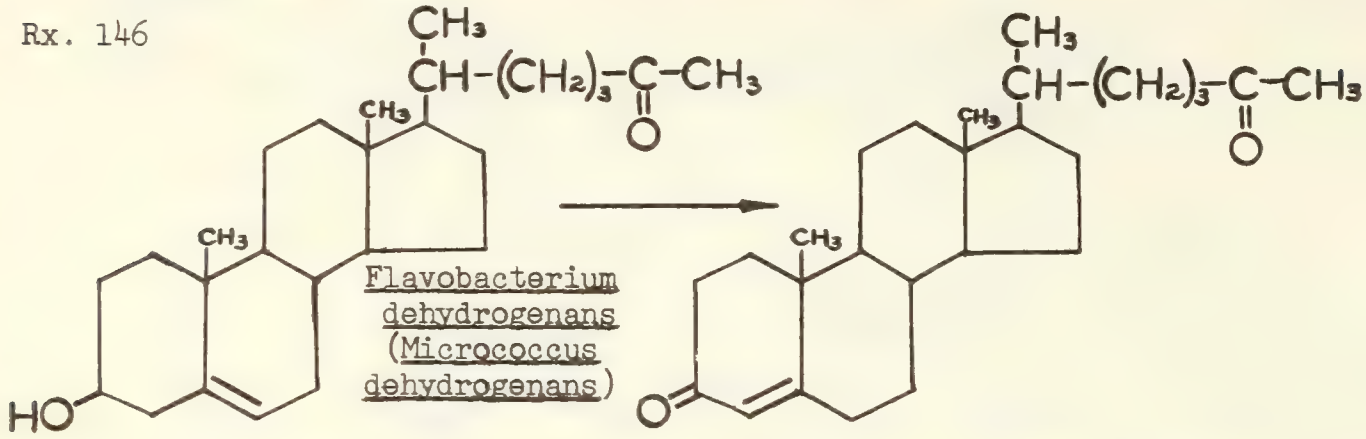


cholic acid — 3α,7α-dihydroxy-12-keto-bisnorcholanic acid

Ercoli, Boll. sci. facoltà chim. ind. Bologna, 279-82 (1940).

C.A. 38, 1540[8] (1944).

Rx. 146



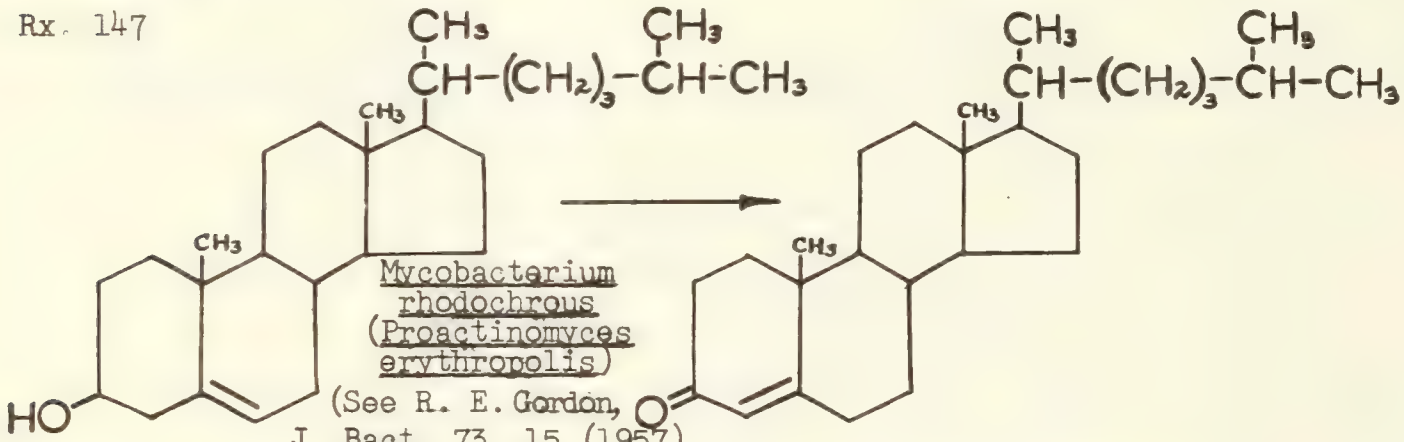
Δ^5-norcholestene-3-ol-25-one

Δ^4-norcholestene-3,25-dione (14%)

Turfitt, Biochem. J. 38, 492-6 (1944).

C.A. 39, 3029[9] (1945).

Rx. 147



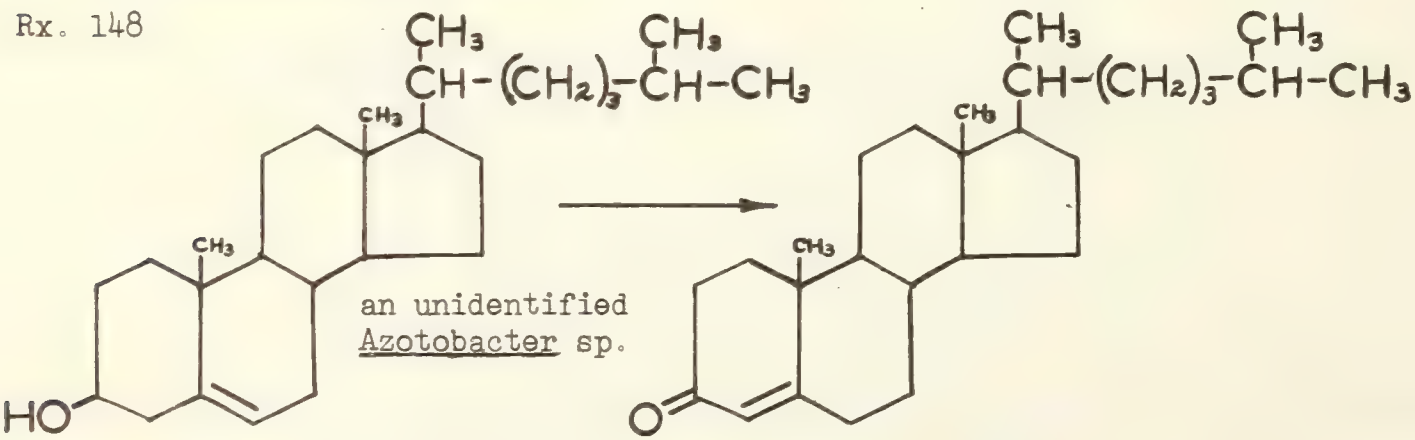
cholesterol

Δ^4-cholestenone

Horvath and Krámli, Nature 160, 639 (1947). (See C.A. 45, 2055d (1951).)

C.A. 42, 1986i (1948).

Rx. 148



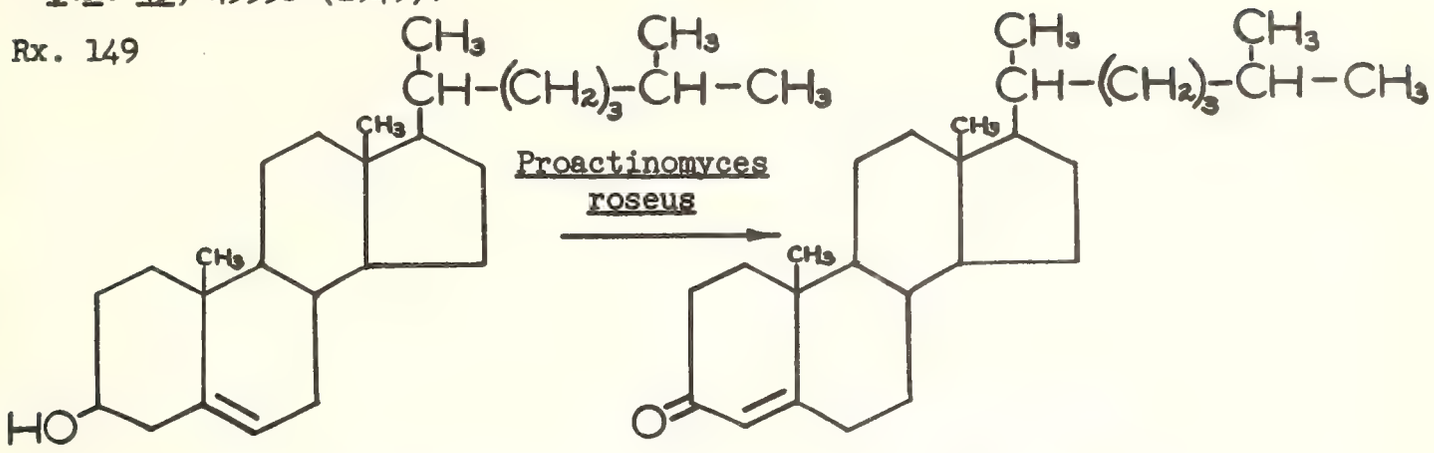
cholesterol

Δ^4-cholestenone

Krámli and Horváth, Nature 162, 619 (1948).

C.A. 43, 4333f (1949).

Rx. 149

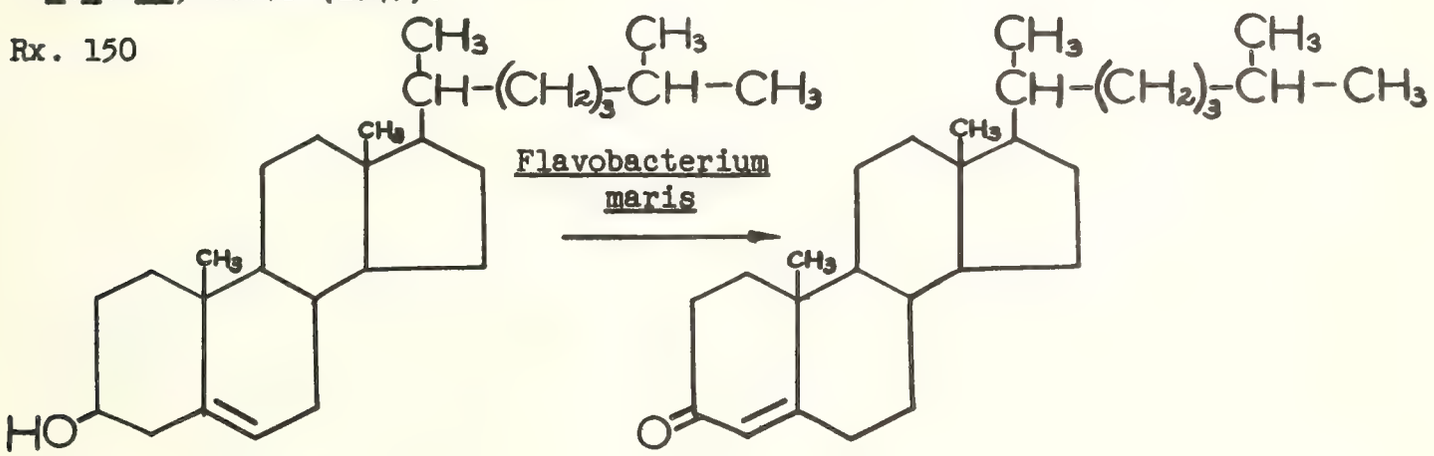


cholesterol — Δ^4-cholestenone

Arnaudi and Colla, Experientia 5, 120-2 (1949).

C.A. 43, 7079f (1949).

Rx. 150

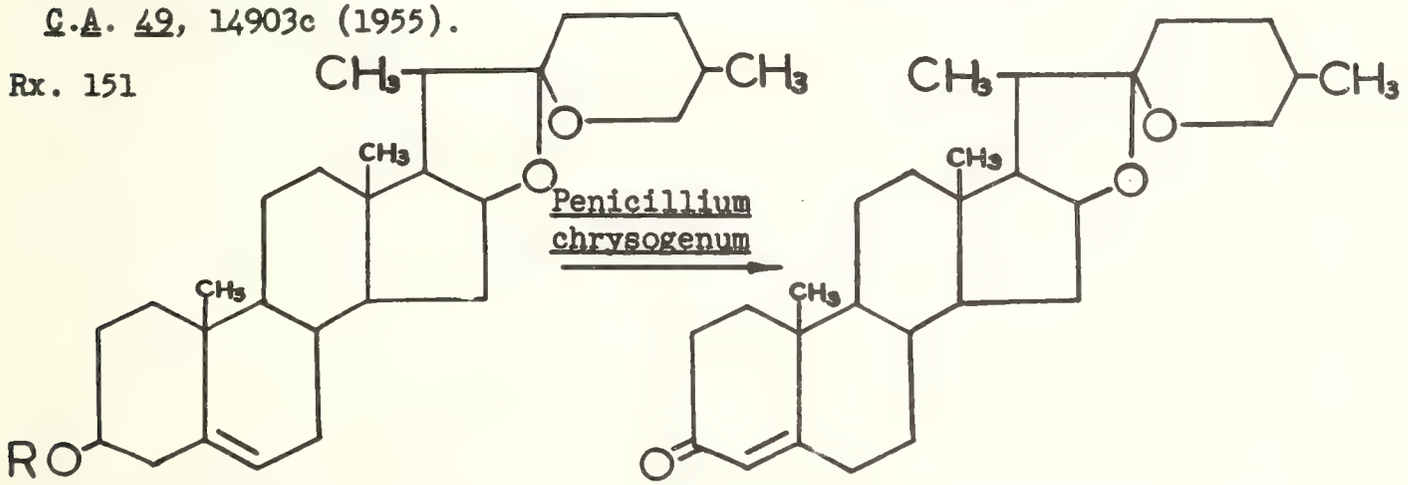


cholesterol — Δ^4-cholestenone (11-13%)

Rothrock et al., Arch. Biochem. Biophys. 57, 151-5 (1955).

C.A. 49, 14903c (1955).

Rx. 151



saponin (R = carbohydrate moiety) — Δ^4-diosgenone (3.6%)

I. Oxidation

b. $-CH_2- \longrightarrow -\underset{\displaystyle OH}{\overset{|}{C}}H-$

Walker and Coppock, J. Chem. Soc., 803-9 (1928).
C.A. 22, 2394[9] (1928).

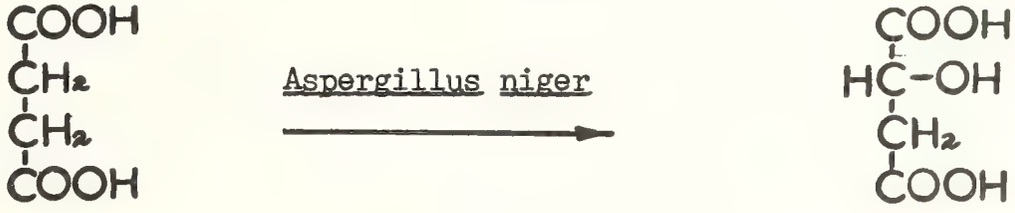
Rx. 152

$CH_3-CH_2-COOH \xrightarrow{\text{Aspergillus niger}} CH_3-\underset{\displaystyle OH}{\overset{|}{C}}H-COOH$

propionic acid — lactic acid

Stent, Subramaniam and Walker, J. Chem. Soc., 1987-93 (1929).
C.A. 24, 4072[5] (1930).

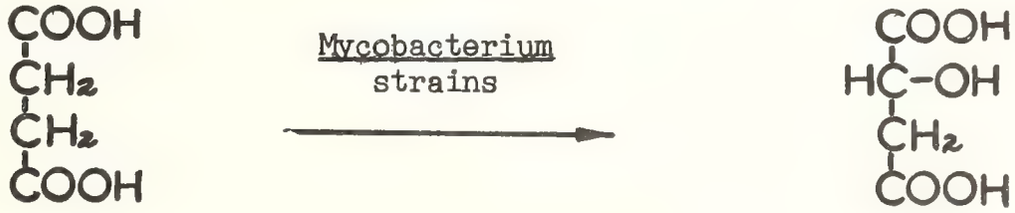
Rx. 153



succinic acid — dl- and l-malic acid (7.3%)

Lassota et al., Bull. acad. polon. sci. Classe II, 3 [1], 11-14 (1955).
C.A. 50, 5080b (1956).

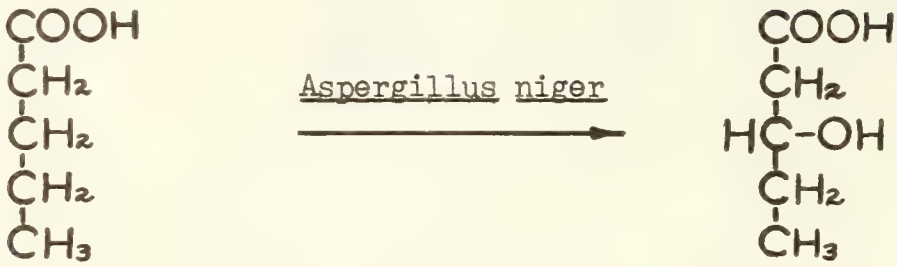
Rx. 154



succinic acid — malic acid

Coppock et al., J. Chem. Soc., 1422-7 (1928).
C.A. 22, 3425[5] (1928).

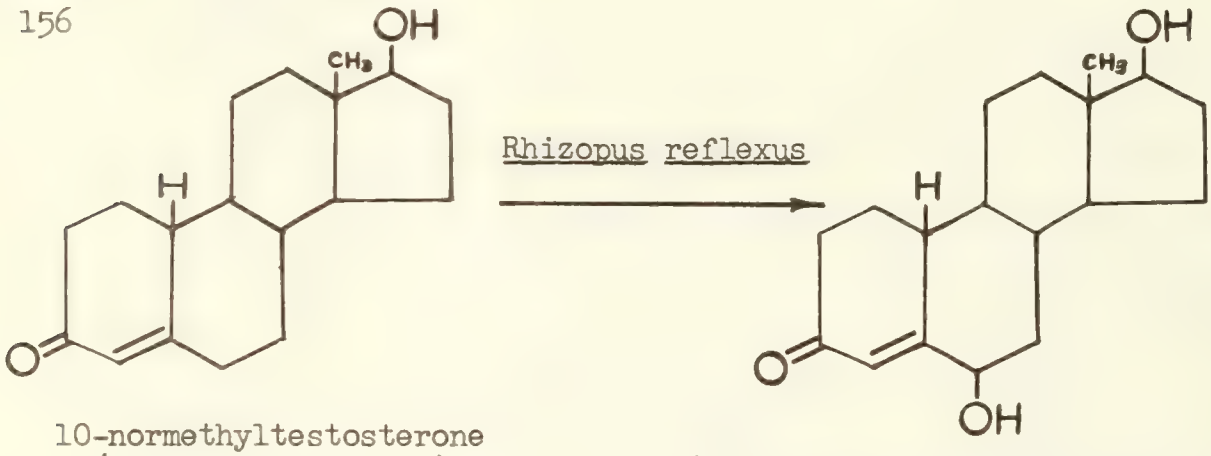
Rx. 155



valeric acid — β-hydroxyvaleric acid

Murray and Peterson, U.S. 2,683,725 (July 13, 1954).
C.A. 49, 7608a (1955).

Rx. 156

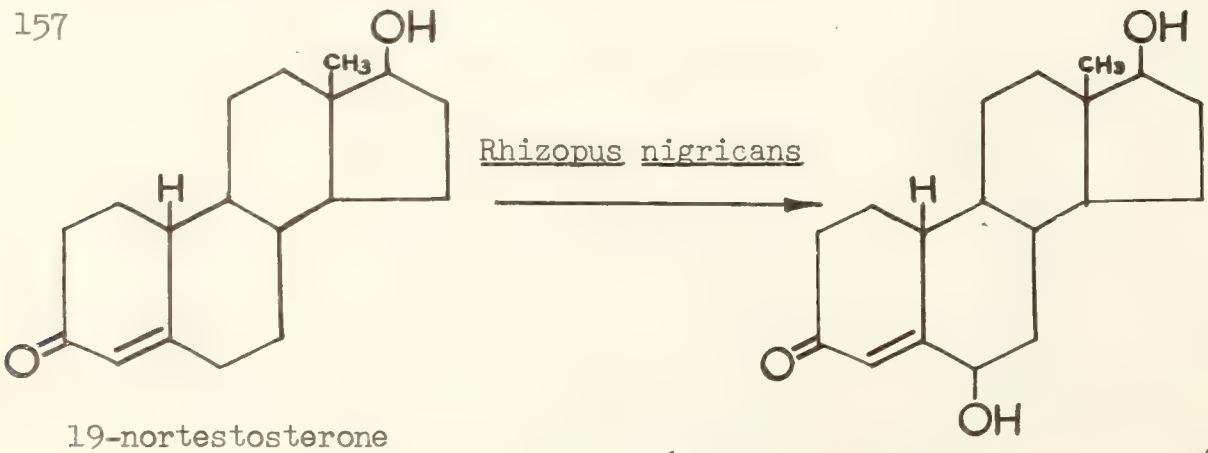


10-normethyltestosterone
(19-nortestosterone)

6β-hydroxy-10-normethyltestosterone

Pederson et al., J. Am. Chem. Soc. 78, 1512-13 (1956).
C.A. 50, 14806d (1956).

Rx. 157



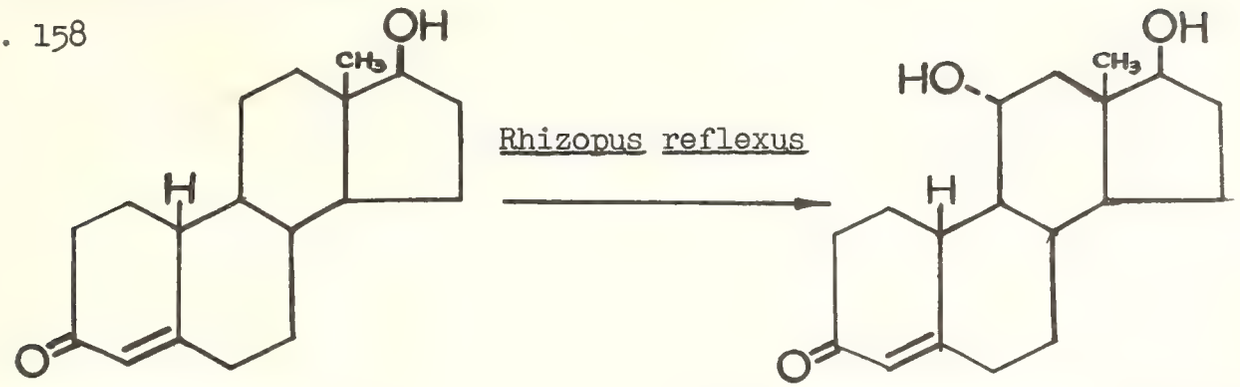
19-nortestosterone

6β-hydroxy-19-nortestosterone (18.3%)

Murray and Peterson, U.S. 2,683,725 (July 13, 1954).

C.A. 49, 7608a (1955).

Rx. 158



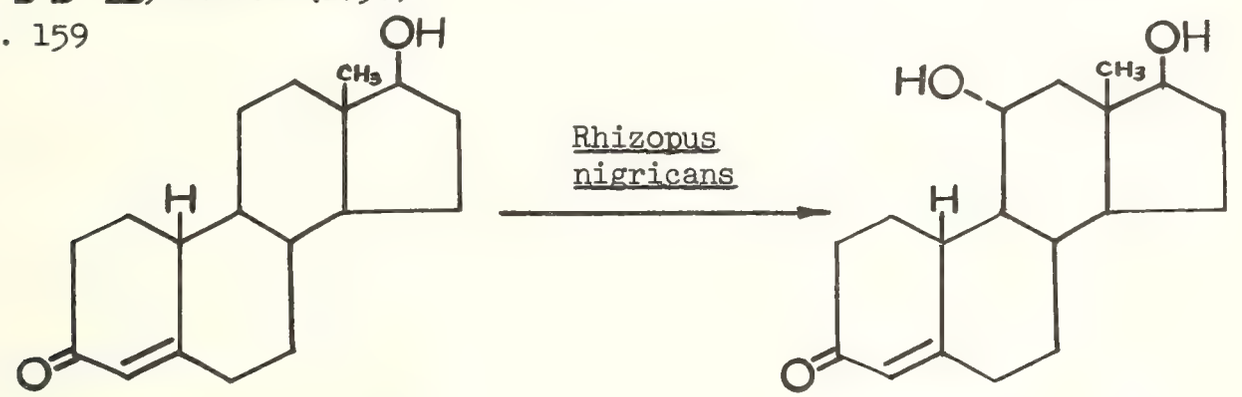
10-normethyltestosterone — 11α-hydroxy-10-normethyltestosterone

---

Pederson et al., J. Am. Chem. Soc. 78, 1512-13 (1956).

C.A. 50, 14806d (1956).

Rx. 159

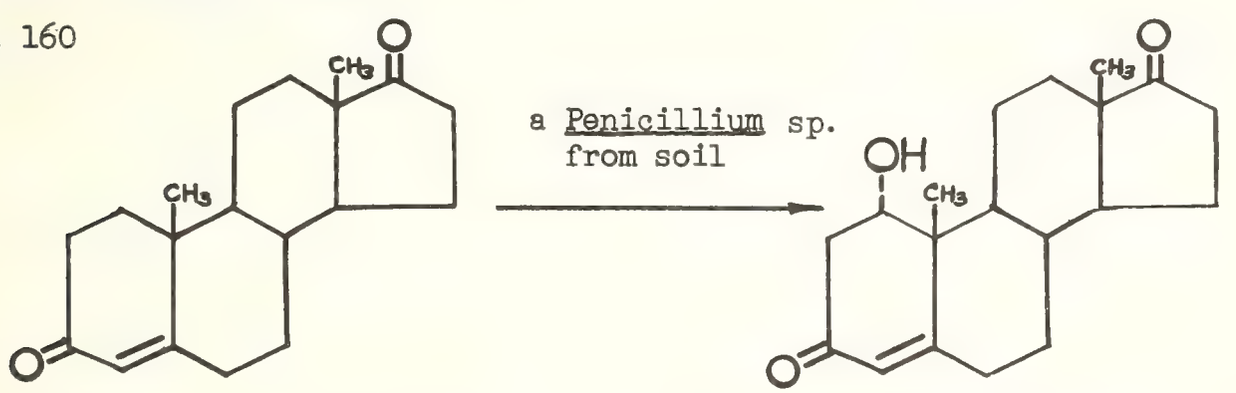


19-nortestosterone — 11α-hydroxy-19-nortestosterone (4.2%)

Dodson et al., J. Am. Chem. Soc. 79, 3921 (1957).

C.A. 51, 18113d (1957).

Rx. 160

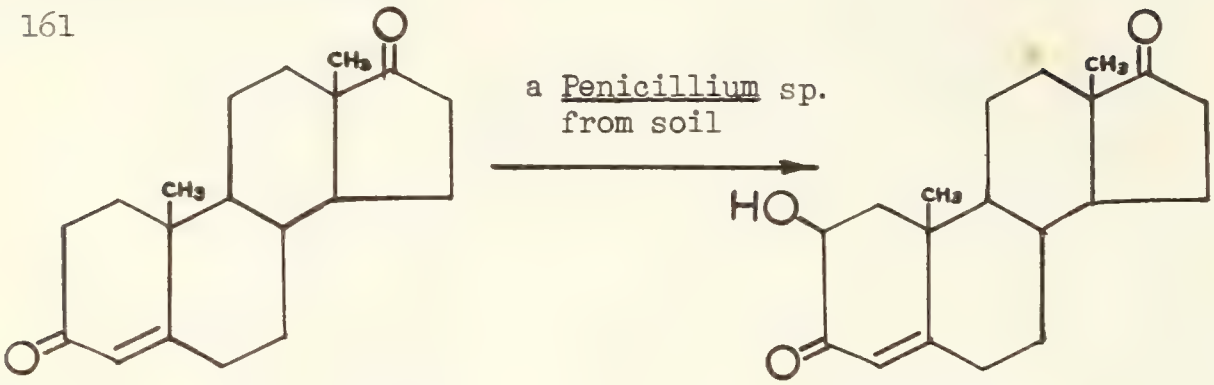


Δ^4-androstene-3,17-dione — 1α-hydroxy-Δ^4-androstene-3,17-dione

Dodson et al., J. Am. Chem. Soc. 79, 3921 (1957).

C.A. 51, 18113d (1957).

Rx. 161



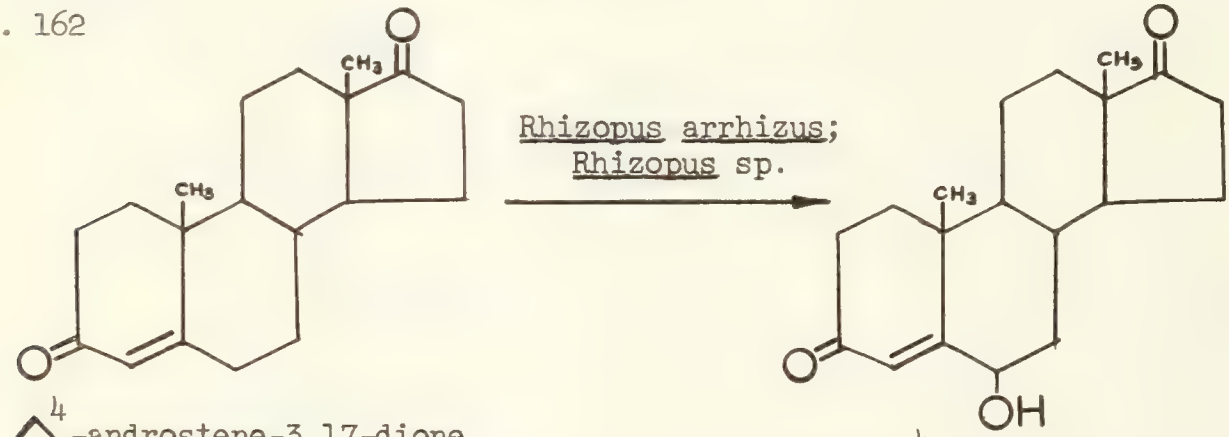
Δ^4-androstene-3,17-dione — 2β-hydroxy-Δ^4-androstene-3,17-dione

---

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954).

C.A. 49, 9021i (1955).

Rx. 162



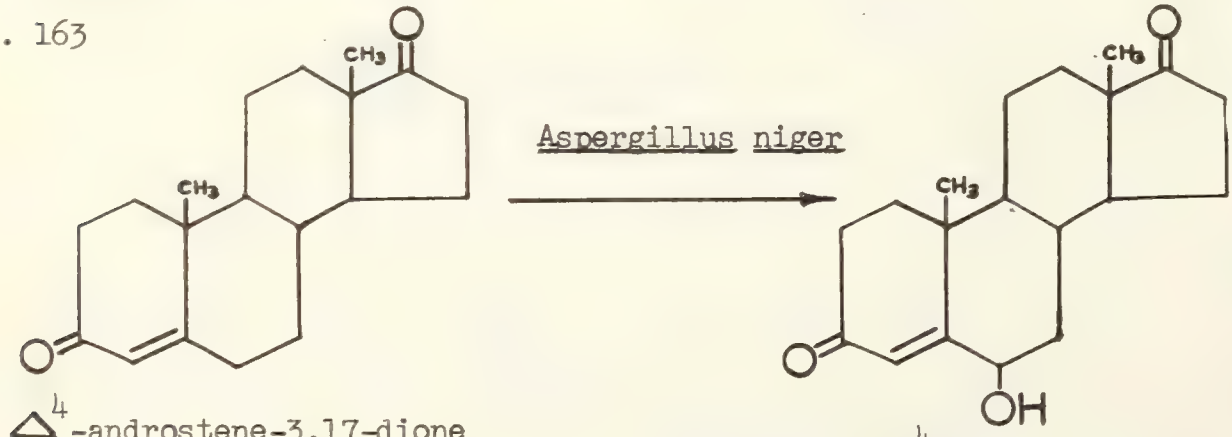
Δ^4-androstene-3,17-dione — 6β-hydroxy-Δ^4-androstene-3,17-dione

---

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 163

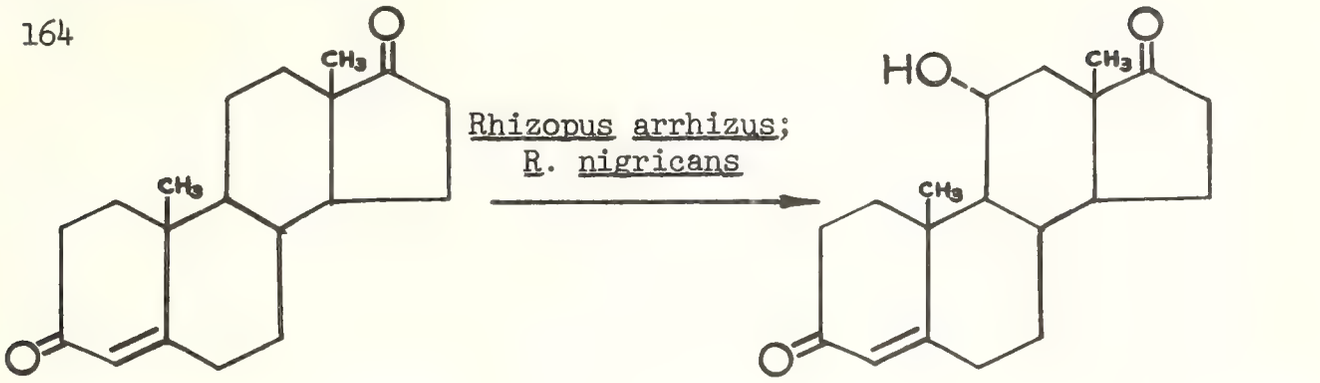


Δ^4-androstene-3,17-dione — 6β-hydroxy-Δ^4-androstene-3,17-dione

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 164



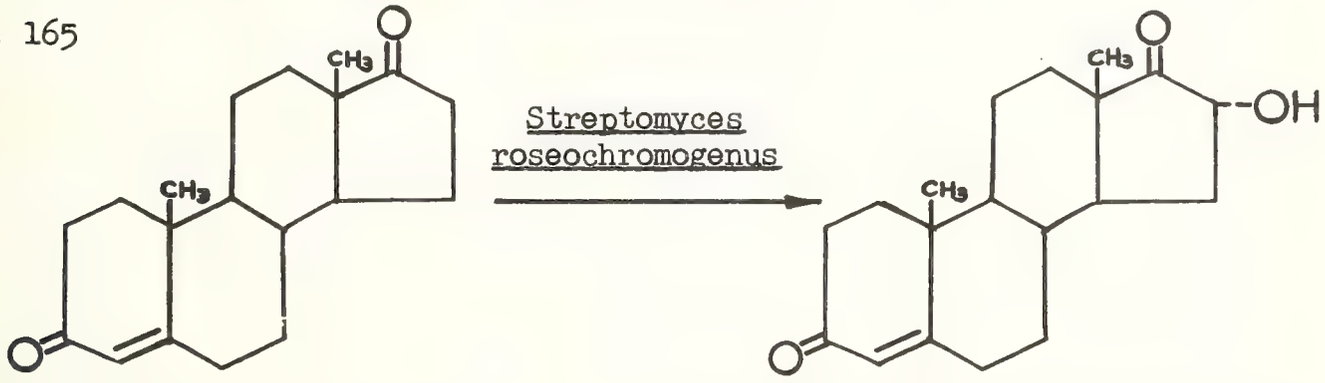
Δ^4-androstene-3,17-dione

11α-hydroxy-Δ^4-androstene-3,17-dione
(approx. 24%)

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 165



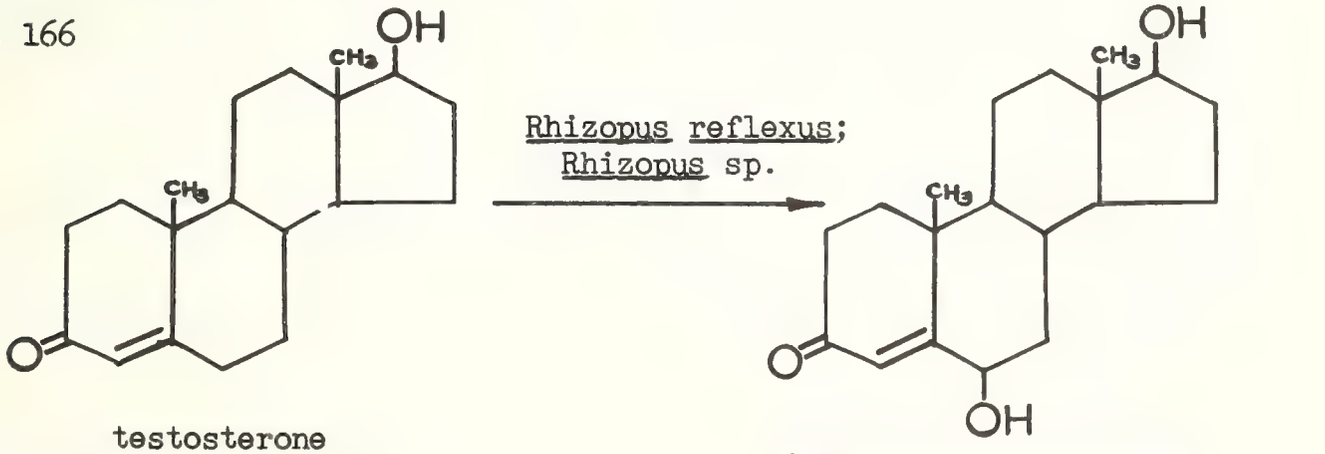
Δ^4-androstene-3,17-dione

16α-hydroxy-Δ^4-androstene-3,17-dione

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954).

C.A. 49, 9021i (1955).

Rx. 166

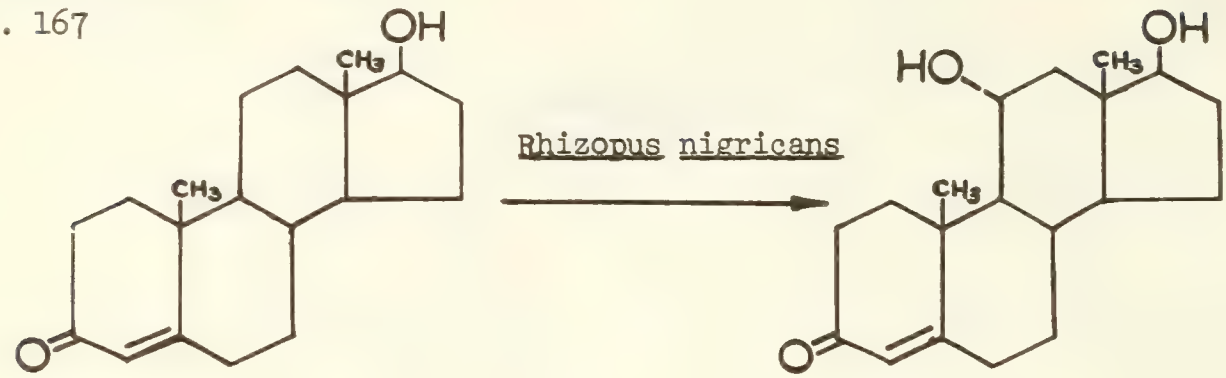


testosterone

6β-hydroxytestosterone

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).
C.A. 46, 8331f (1952)

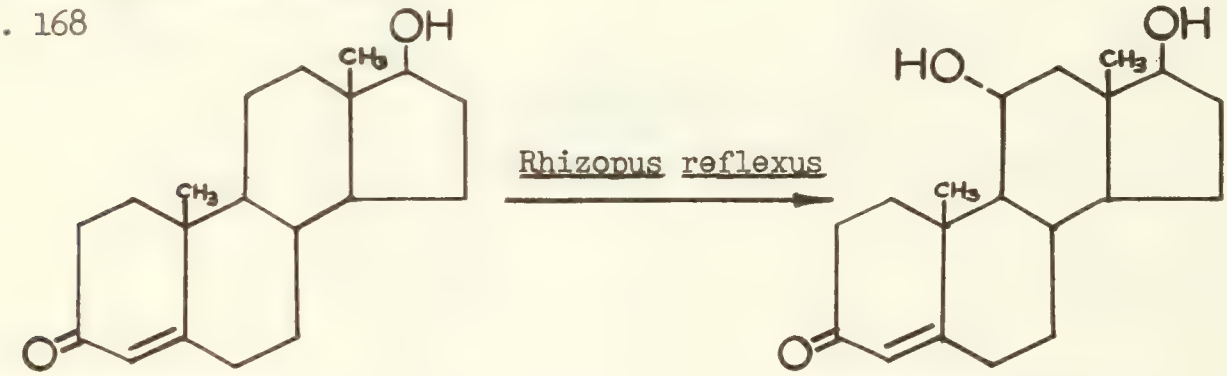
Rx. 167



testosterone — 11α-hydroxytestosterone (10.7%)

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954).
C.A. 49, 9021i (1955).

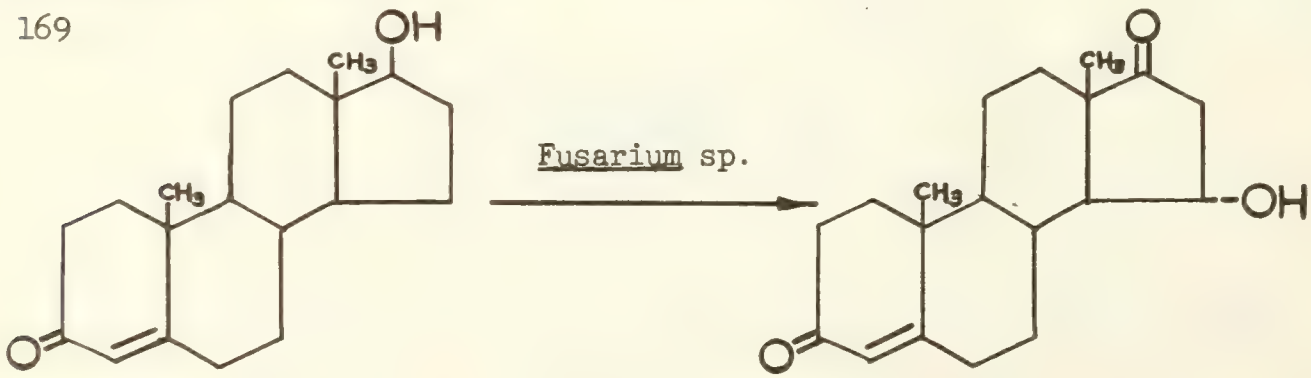
Rx. 168



testosterone — 11α-hydroxytestosterone (43%)

Meister et al. in Peterson, Record Chem. Progr. 17, 211-40 (1956).
C.A. 51, 3635c (1957).

Rx. 169

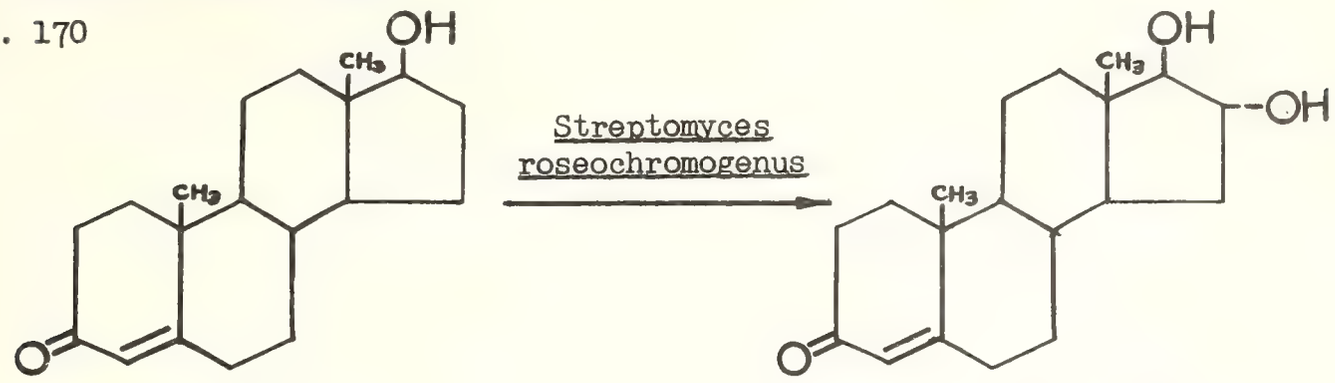


testosterone — 15α-hydroxy-Δ^4-androstene-3,17-dione

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

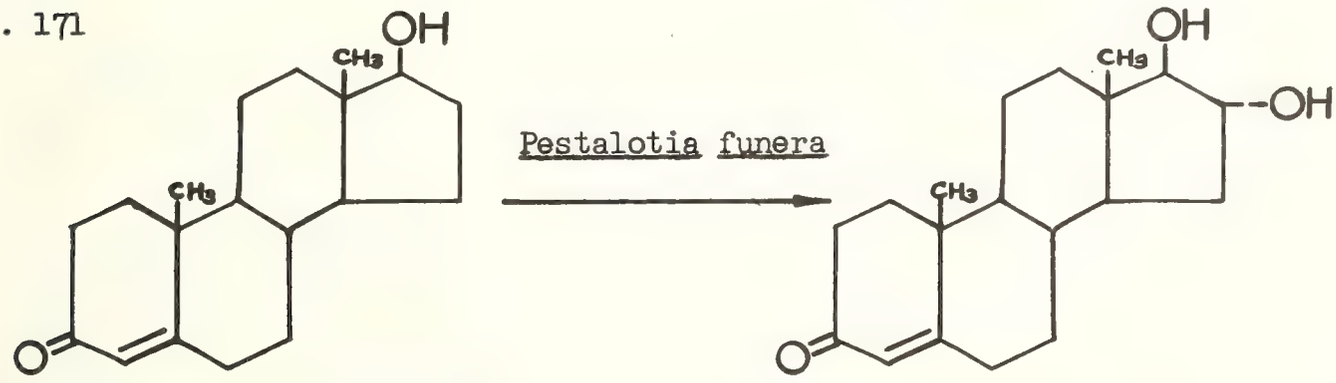
Rx. 170



testosterone — 16α-hydroxytestosterone

Thoma et al., 69th meeting, N.Y.C. Branch of Soc. Am. Bact., New York (1955).

Rx. 171

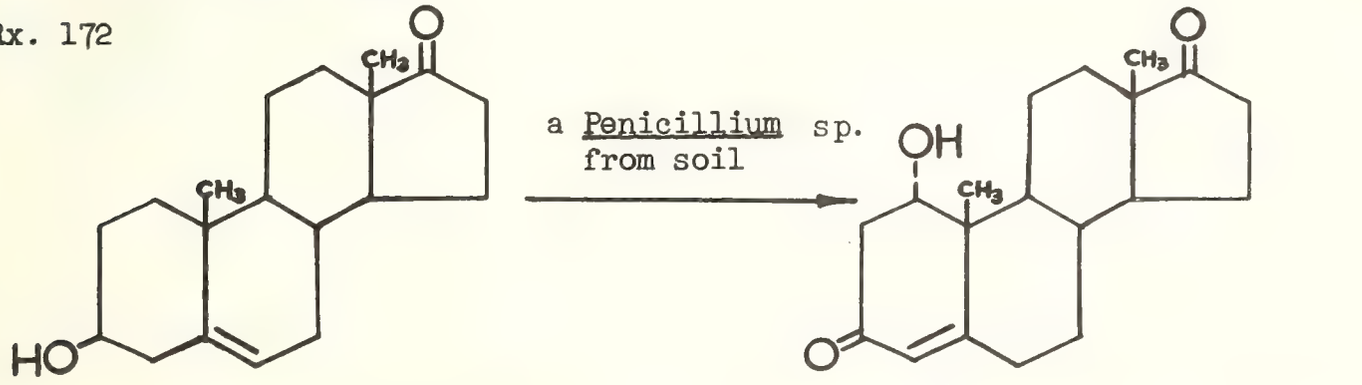


testosterone — 16α-hydroxytestosterone

Dodson et al., J. Am. Chem. Soc. 79, 3921 (1957).

C.A. 51, 18113d (1957).

Rx. 172

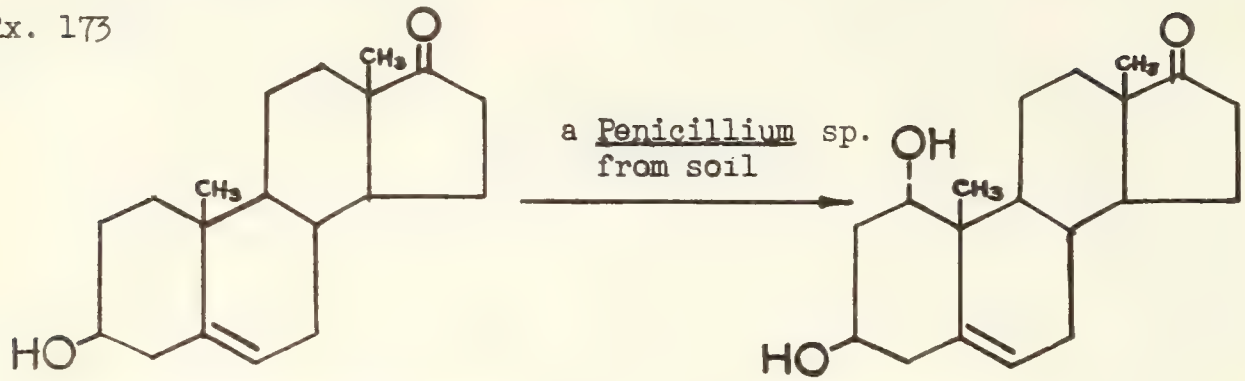


Δ^5-androstene-3β-ol-17-one (dehydroepiandrosterone) — 1α-hydroxy-Δ^4-androstene-3,17-dione

Dodson et al., J. Am. Chem. Soc. 79, 3921 (1957).

C.A. 51, 18113d (1957).

Rx. 173



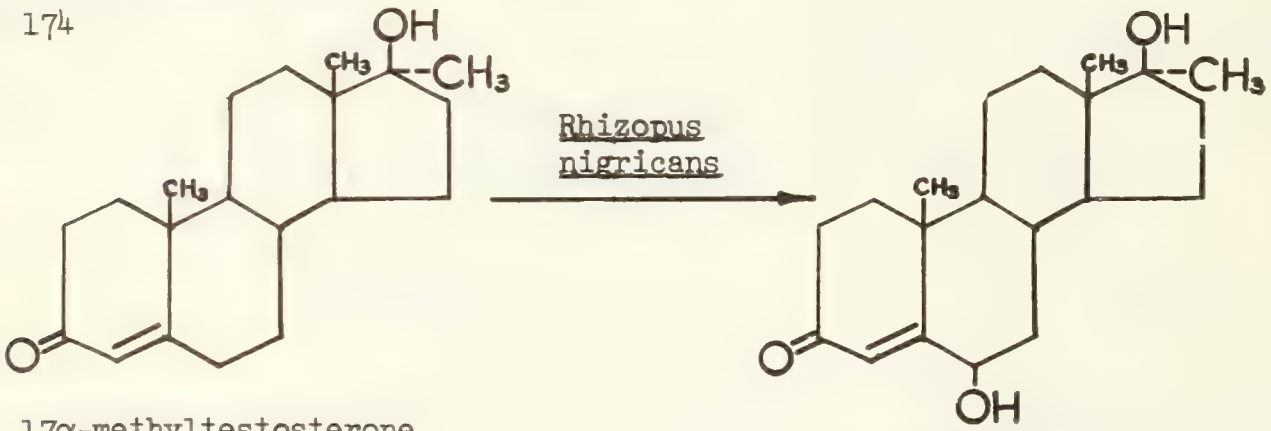
Δ^5-androstene-3β-ol-17-one

Δ^5-androstene-1α,3β-diol-17-one

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954).

C.A. 49, 9021i (1955).

Rx. 174



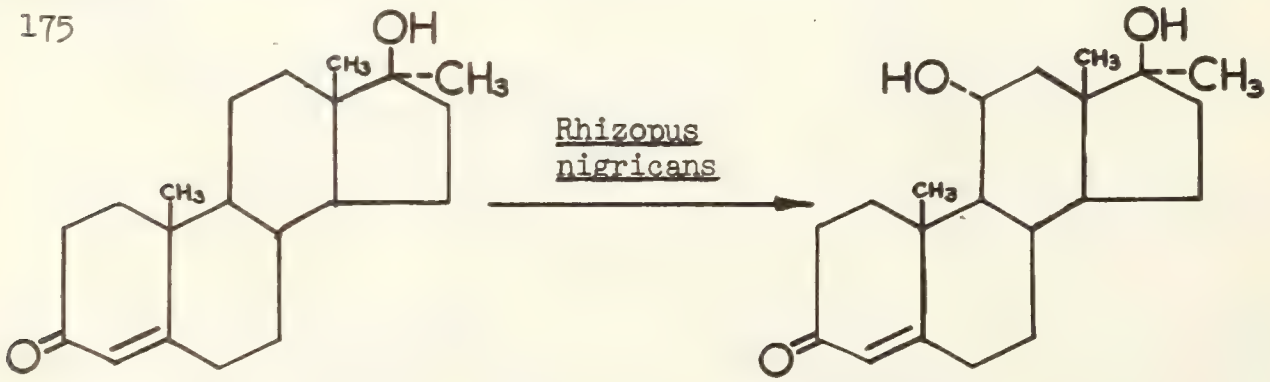
17α-methyltestosterone

6β-hydroxy-17α-methyltestosterone
(4%)

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954).

C.A. 49, 9021i (1955).

Rx. 175



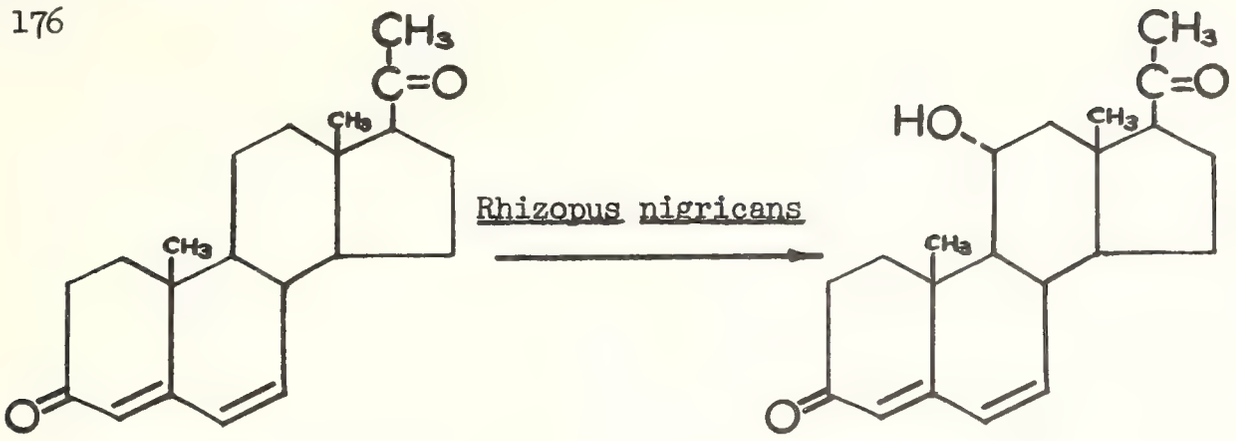
17α-methyltestosterone

11α-hydroxy-17α-methyltestosterone
(47.5%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 176



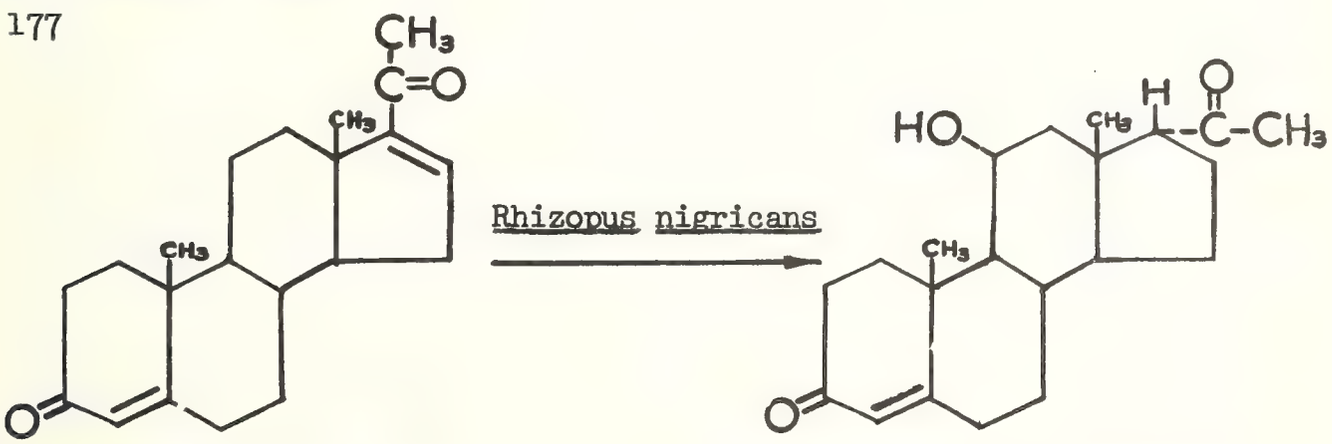
6-dehydroprogesterone

11α-hydroxy-6-dehydroprogesterone (approx. 10%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 177



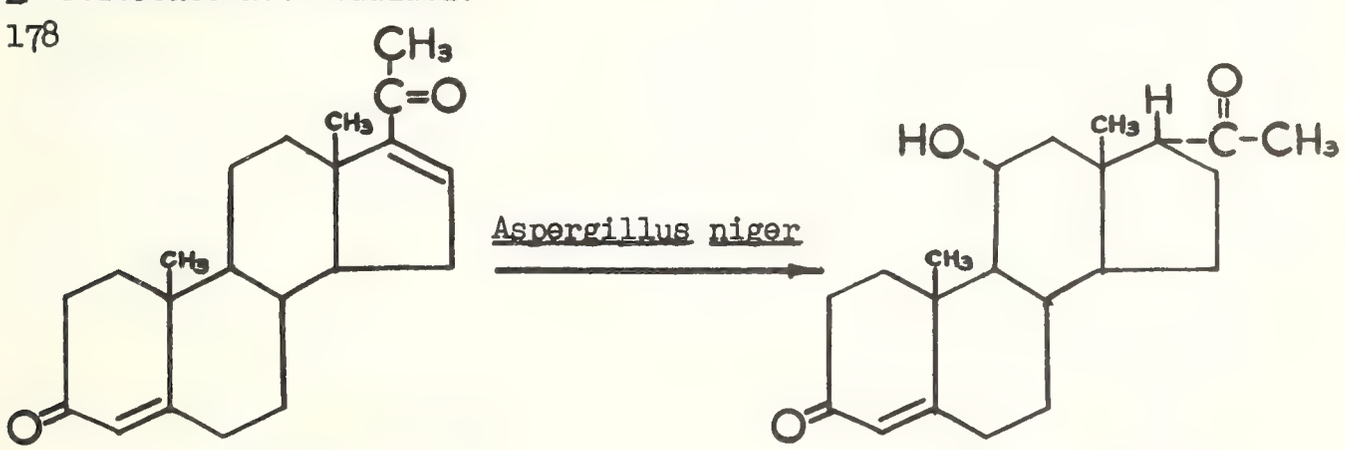
16-dehydroprogesterone

11α-hydroxy-17α-progesterone (24%)

Murray and Peterson, U.S. 2,649,402 (Aug. 18, 1953).

C.A. reference not available

Rx. 178



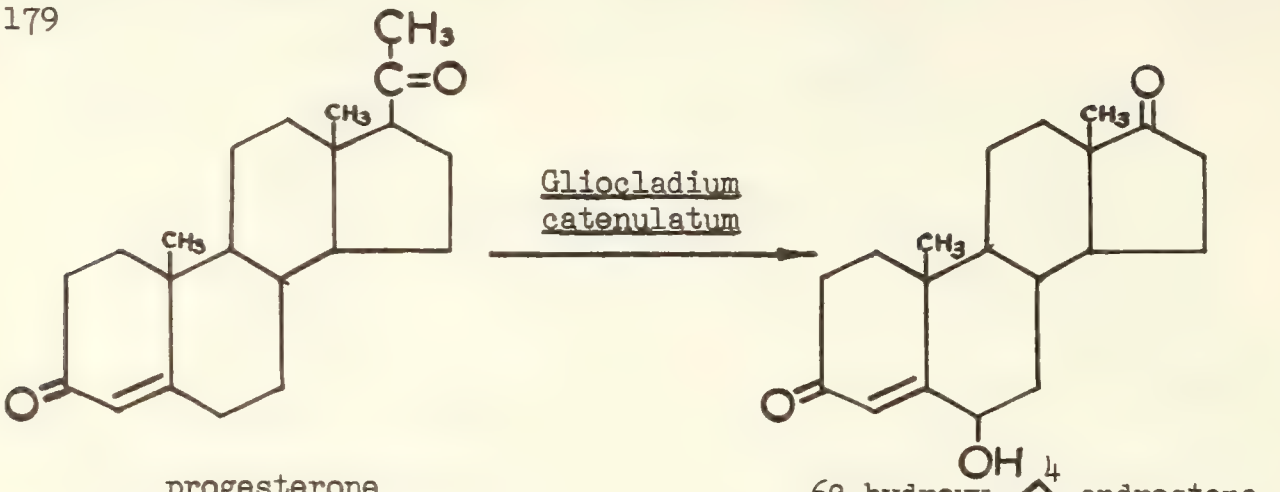
16-dehydroprogesterone

11α-hydroxy-17α-progesterone

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953).

C.A. 49, 366a (1955).

Rx. 179



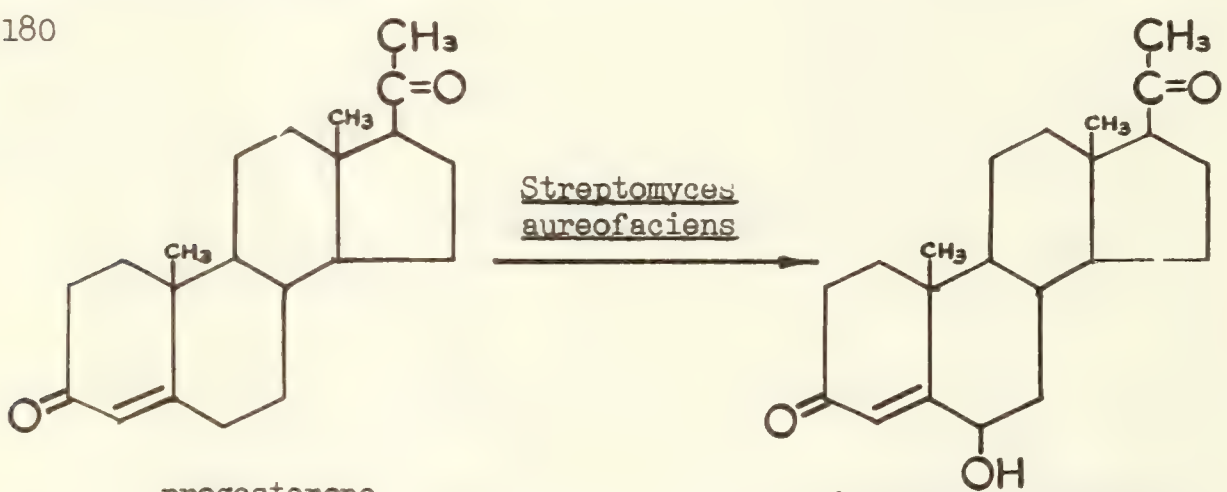
progesterone

6β-hydroxy-Δ⁴-androstene-3,17-dione

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 180



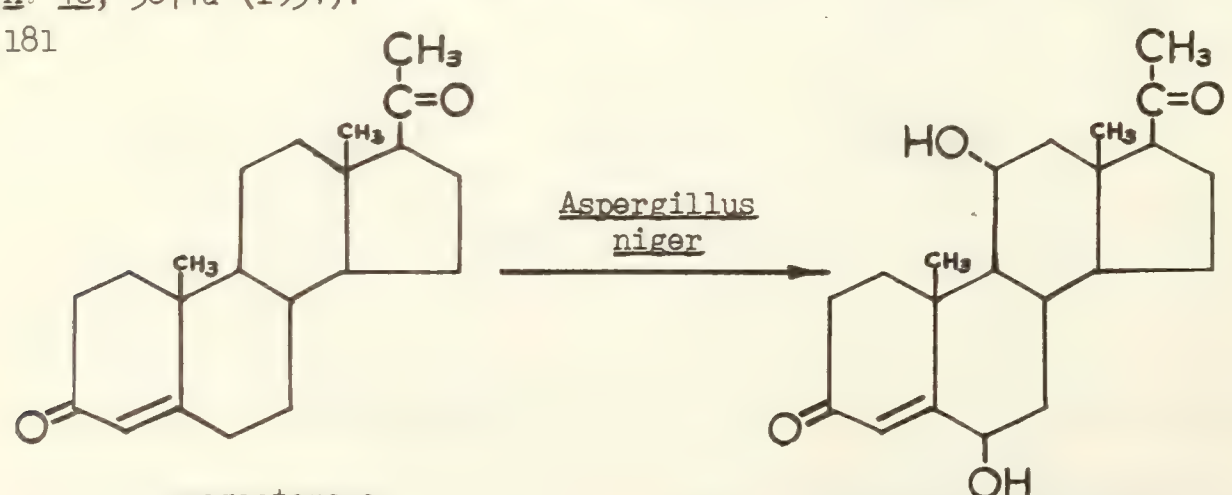
progesterone

6β-hydroxyprogesterone

Fried et al., J. Am. Chem. Soc. 74, 3962-3 (1952).

C.A. 48, 5874a (1954).

Rx. 181



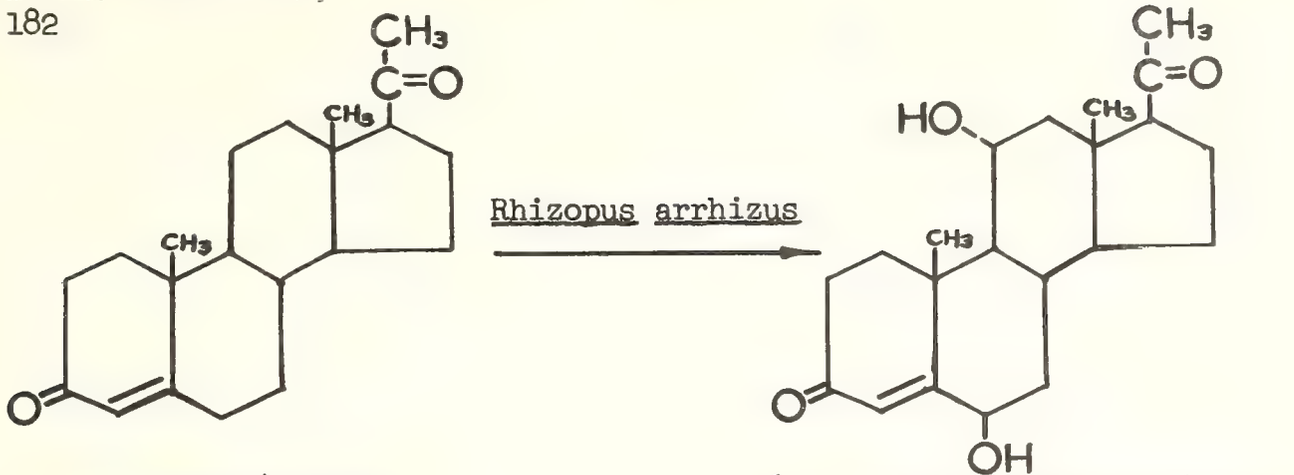
progesterone

6ξ, 11α-dihydroxyprogesterone (20%)
(For C_6 hydroxyl orientation, see JACS 75, 4378 (1953).

Peterson et al., J. Am. Chem. Soc. 74, 5933-6 (1952).

C.A. 47, 4426i (1953).

Rx. 182



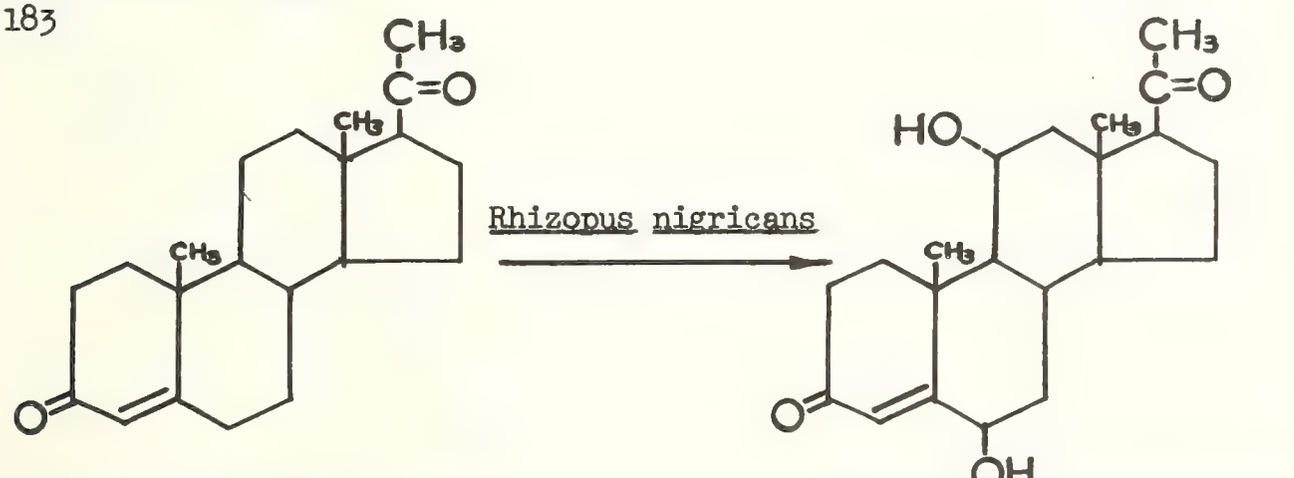
progesterone

6β, 11α-dihydroxyprogesterone
(5-15%)

Peterson et al., J. Am. Chem. Soc. 74, 5933-6 (1952).

C.A. 47, 4426i (1953).

Rx. 183



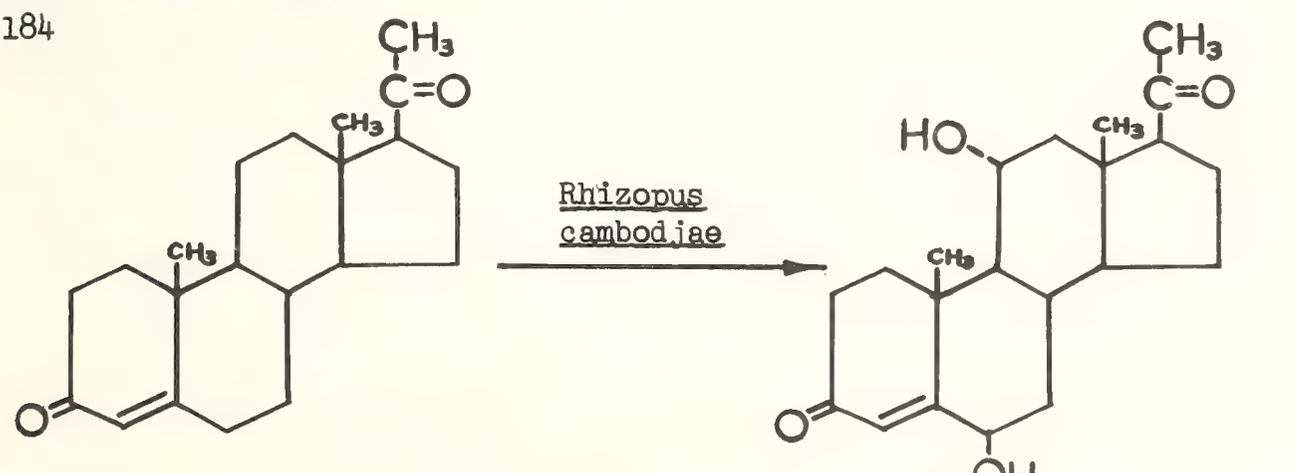
progesterone

6β, 11α-dihydroxyprogesterone
(2%)

Camerino et al., Gazz. chim. ital. 84, 301-11 (1954).

C.A. 49, 14787b (1955).

Rx. 184



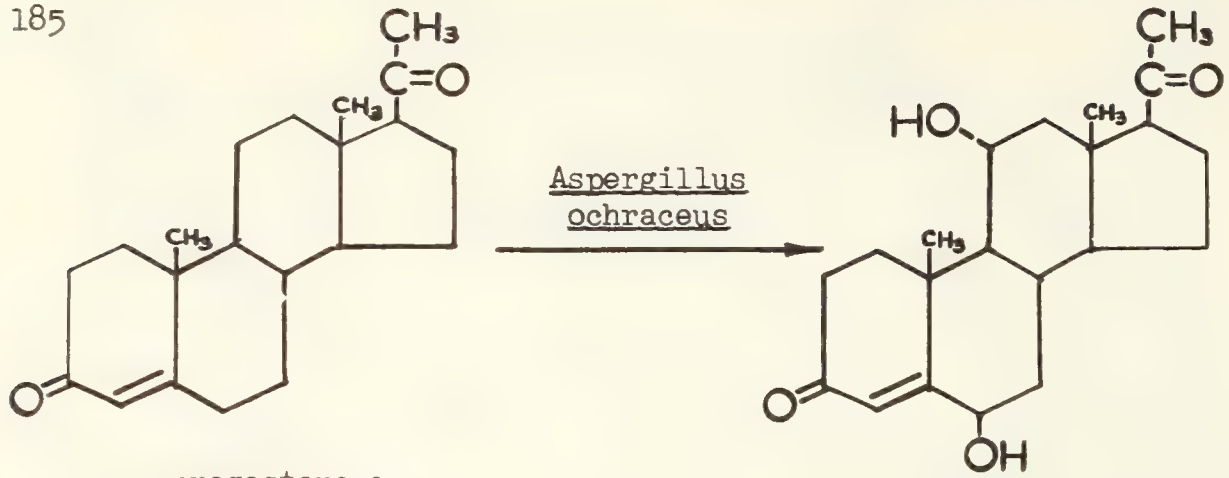
progesterone

6β, 11α-dihydroxyprogesterone
(30%)

Dulaney et al., Mycologia 47, 464-74 (1955).

C.A. reference not available

Rx. 185



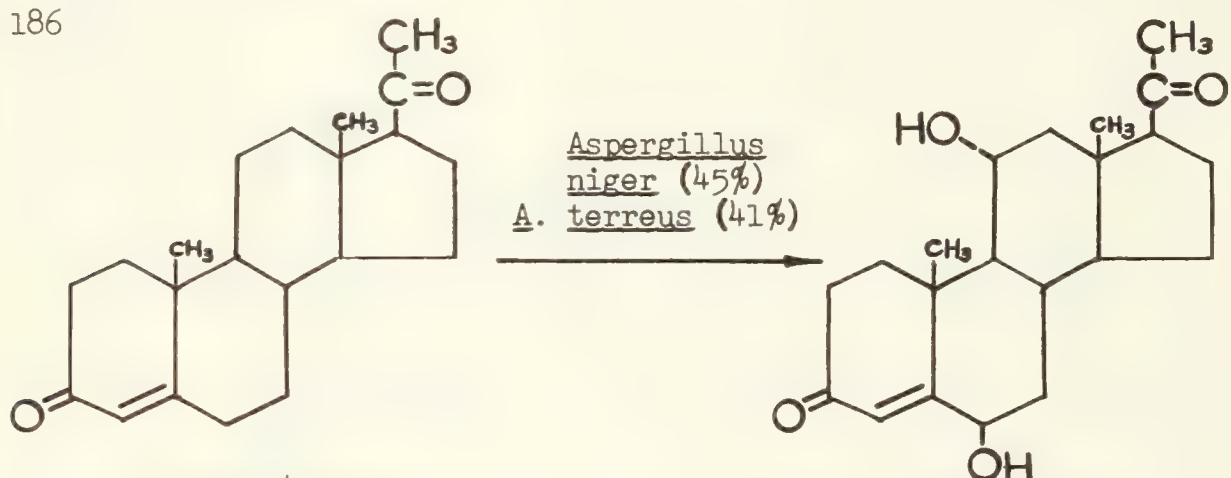
progesterone

6β, 11α-dihydroxyprogesterone

Dulaney et al., Appl. Microbiol. 3, 336-40 (1955).

C.A. 50, 3555e (1956).

Rx. 186



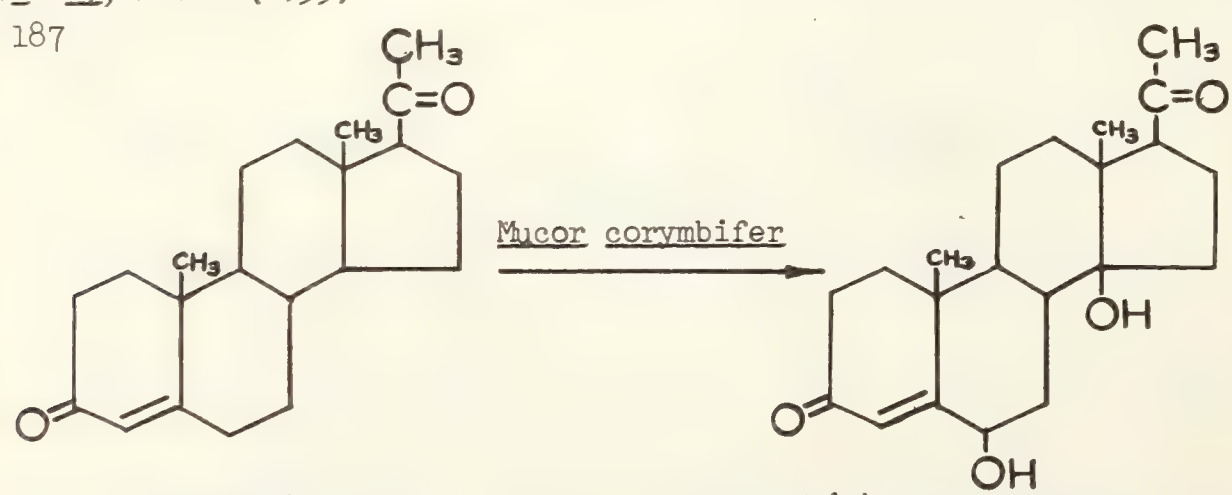
progesterone

6β, 11α-dihydroxyprogesterone

Camerino et al., Gazz. chim. ital. 83, 684-92 (1953).

C.A. 49, 2468d (1955).

Rx. 187



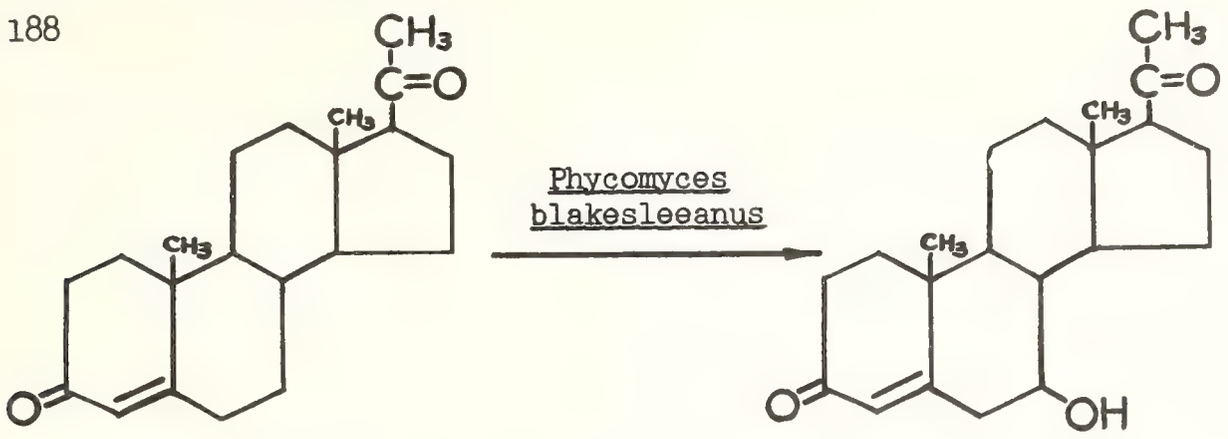
progesterone

6β, 14(?)-dihydroxyprogesterone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 188

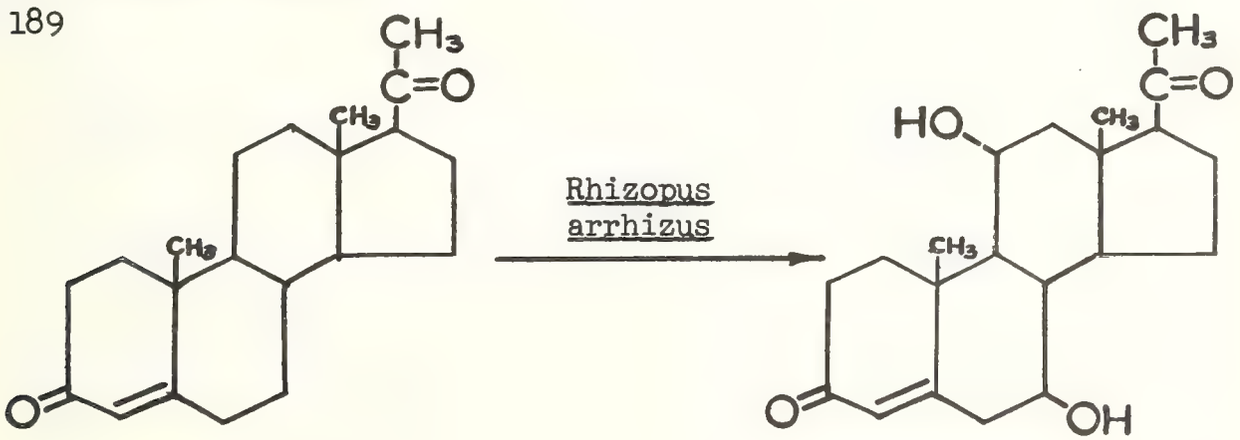


progesterone — 7-hydroxyprogesterone

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 189

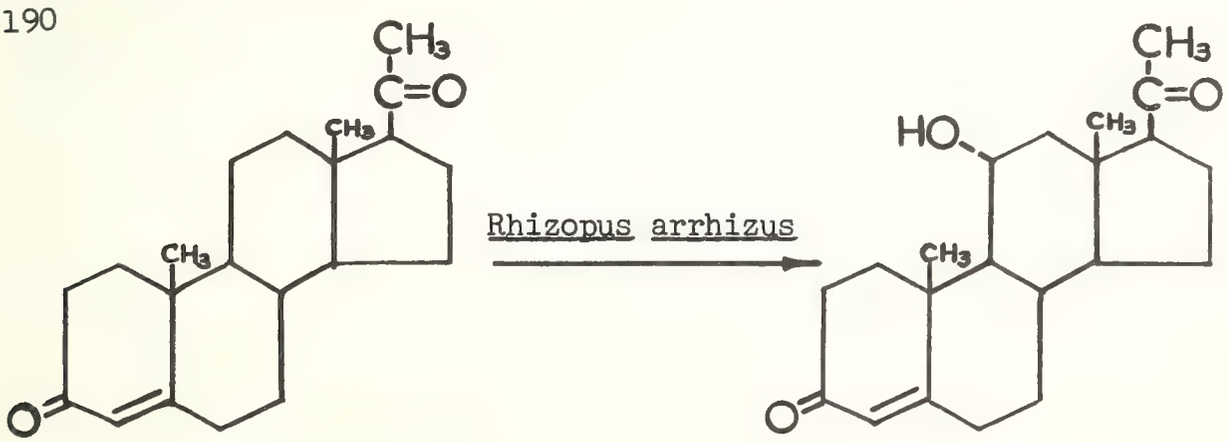


progesterone — 7,11α-dihydroxyprogesterone (38%)

Peterson and Murray, J. Am. Chem. Soc. 74, 1871-2 (1952).

C.A. 47, 6473i (1953).

Rx. 190

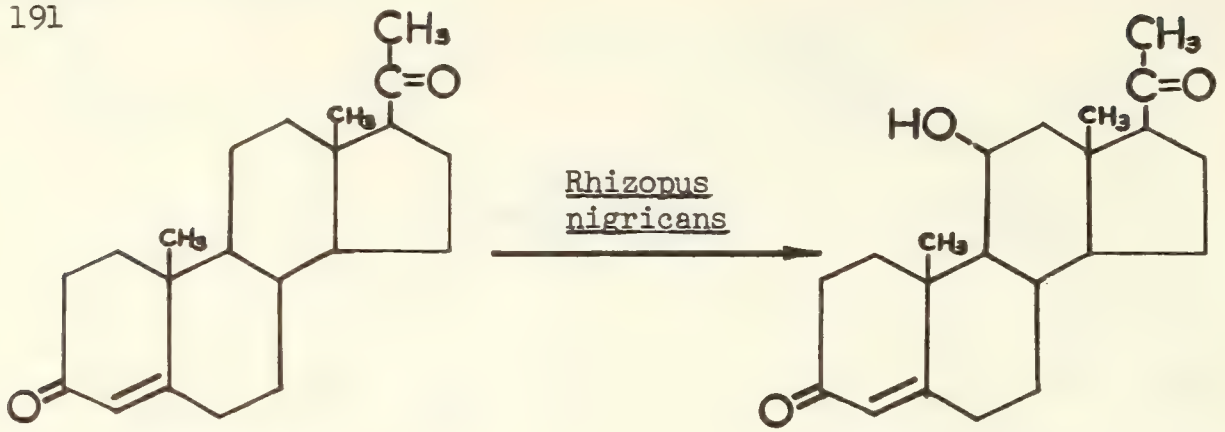


progesterone — 11α-hydroxyprogesterone (10%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 191

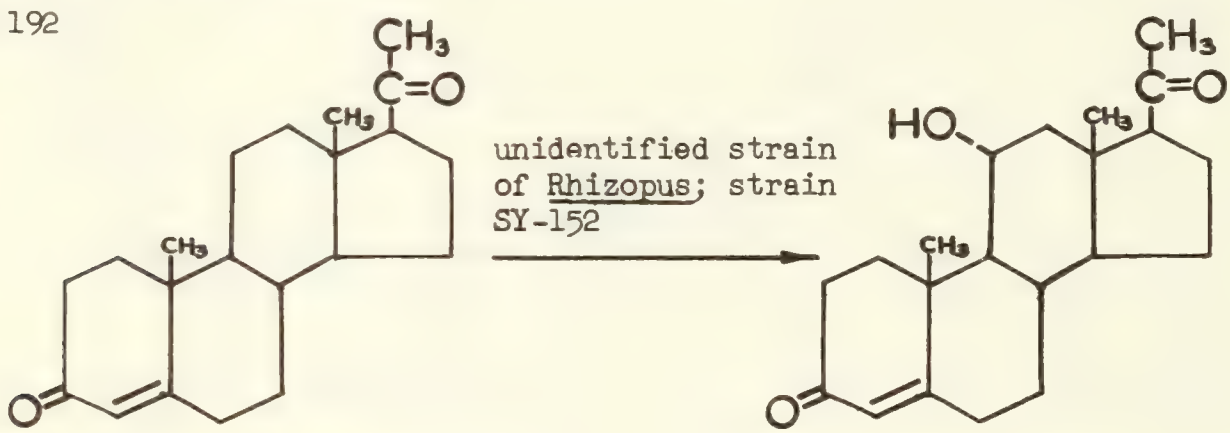


progesterone — 11α-hydroxyprogesterone (80%)

Mancera et al., J. Am. Chem. Soc. 74, 3711-12 (1952).

C.A. 48, 5870d (1954).

Rx. 192

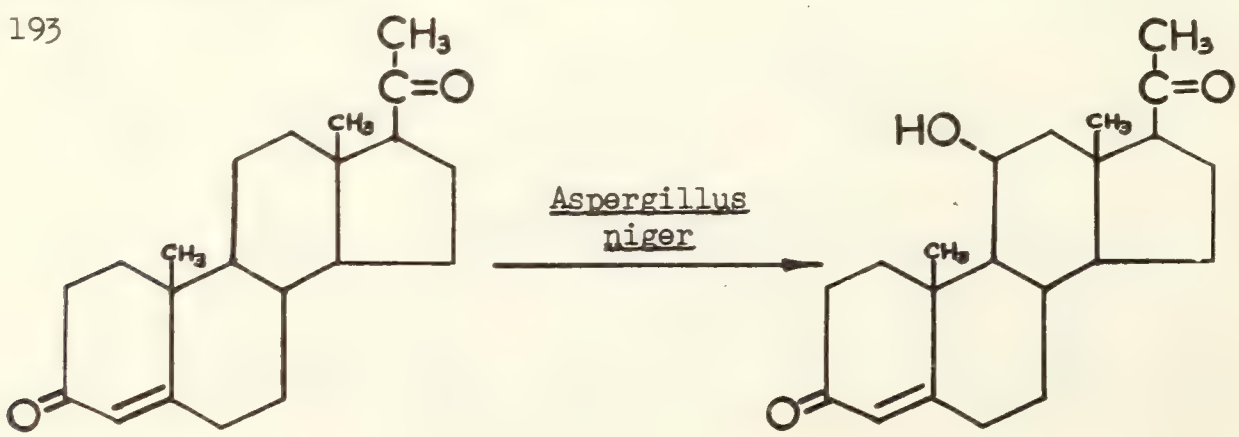


progesterone — 11α-hydroxyprogesterone (45%)

Fried et al., J. Am. Chem. Soc. 74, 3962-3 (1952).

C.A 48, 5874a (1954).

Rx. 193

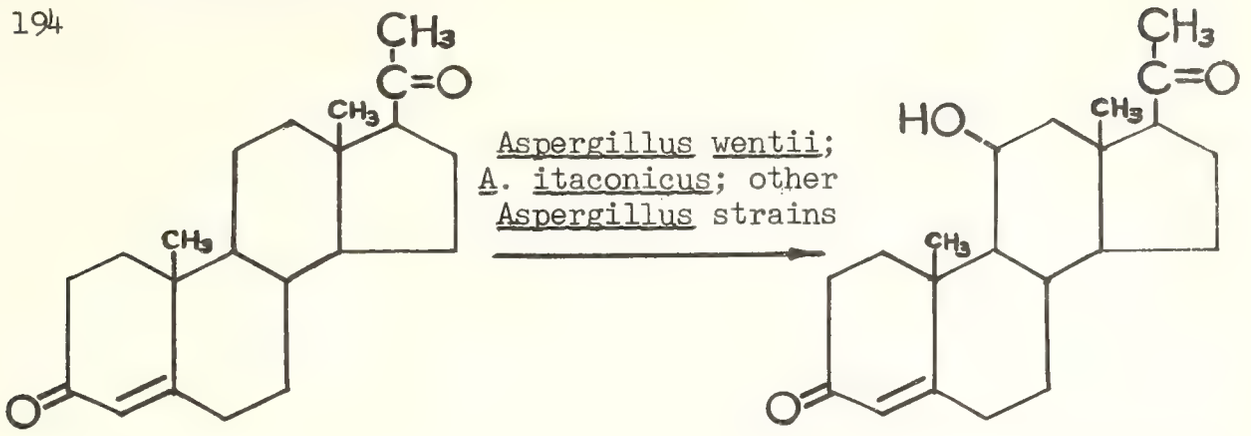


progesterone — 11α-hydroxyprogesterone (35%)

Murray and Peterson, U.S. 2,649,402 (Aug. 18, 1953).

C.A. reference not available

Rx. 194

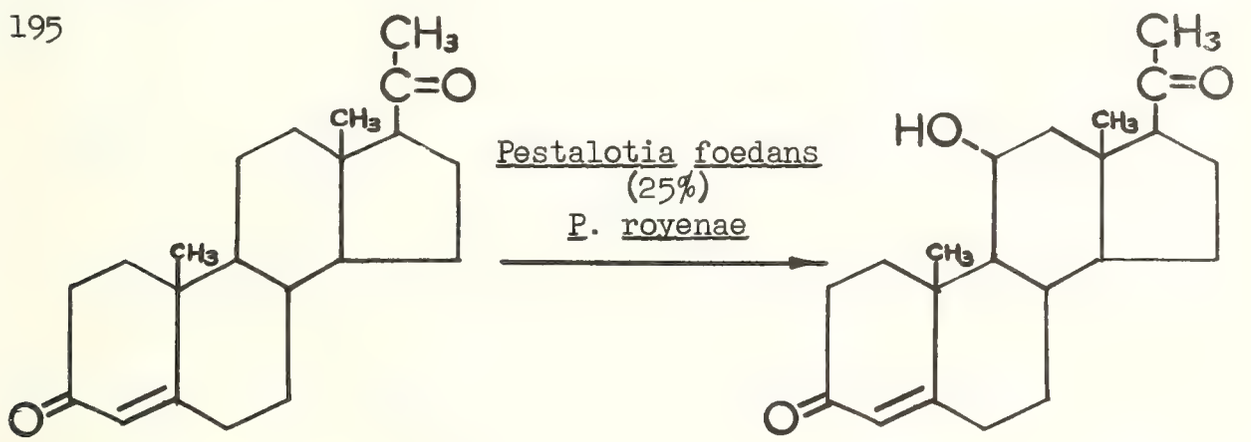


progesterone — 11α-hydroxyprogesterone

Shull et al., Can. 507,009 (Nov. 2, 1954). (See U.S. 2,721,163 in C.A. 50, 2128h).

C.A. reference not available

Rx. 195

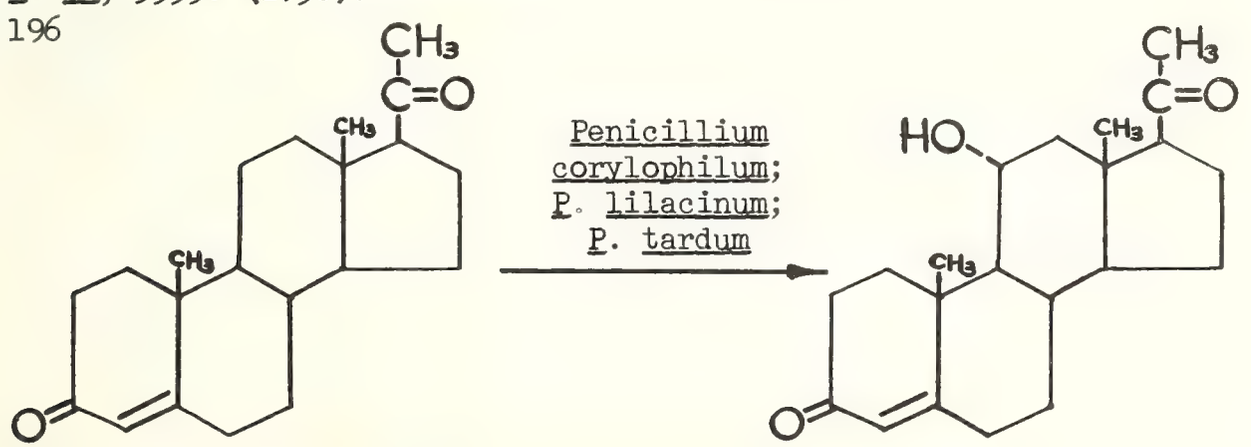


progesterone — 11α-hydroxyprogesterone

Dulaney et al., Appl. Microbiol. 3, 336-40 (1955).

C.A. 50, 3555e (1956).

Rx. 196

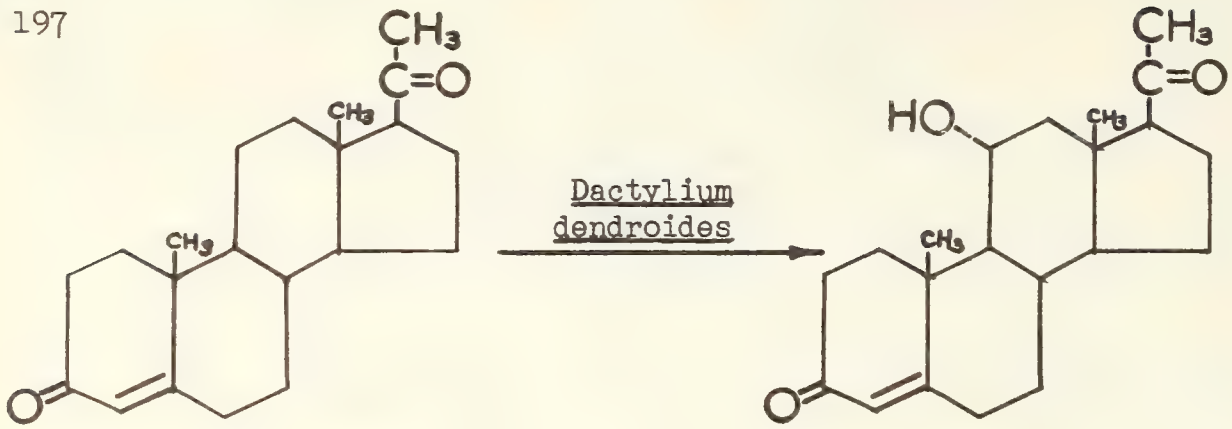


progesterone — 11α-hydroxyprogesterone

Dulaney et al., Appl. Microbiol. 3, 372-4 (1955).

C.A. 50, 2741c (1956).

Rx. 197

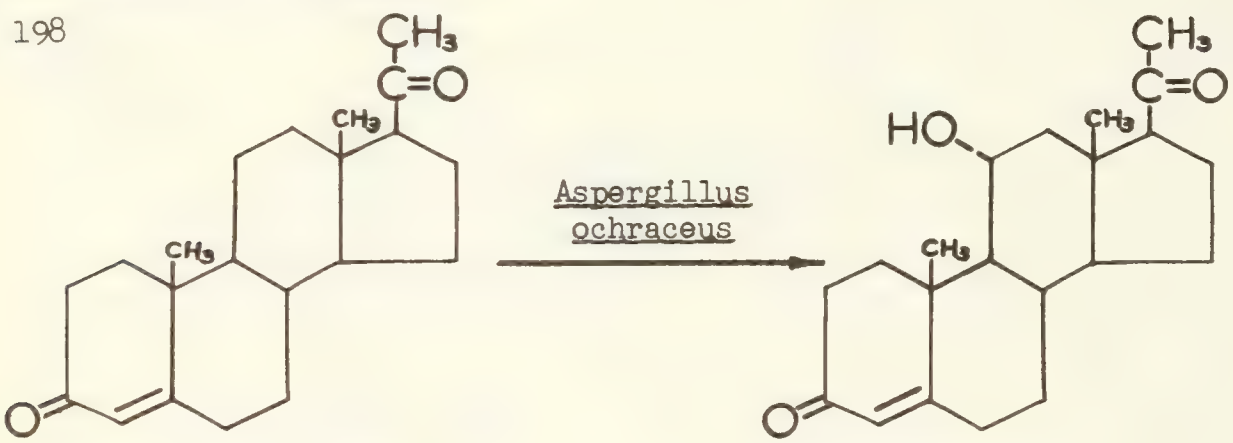


progesterone — 11α-hydroxyprogesterone (30.8%)

Dulaney et al., Mycologia 47, 464-74 (1955).

C.A. reference not available

Rx. 198

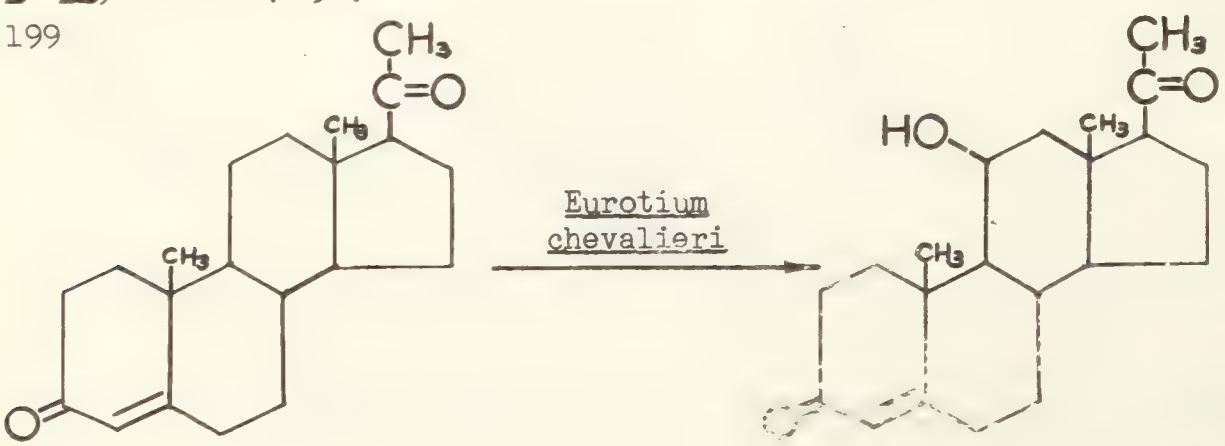


progesterone — 11α-hydroxyprogesterone (87%)

Pfizer (Chas.) and Co., Inc., Brit. 740,858 (Nov. 23, 1955).

C.A. 50, 10809d (1956).

Rx. 199

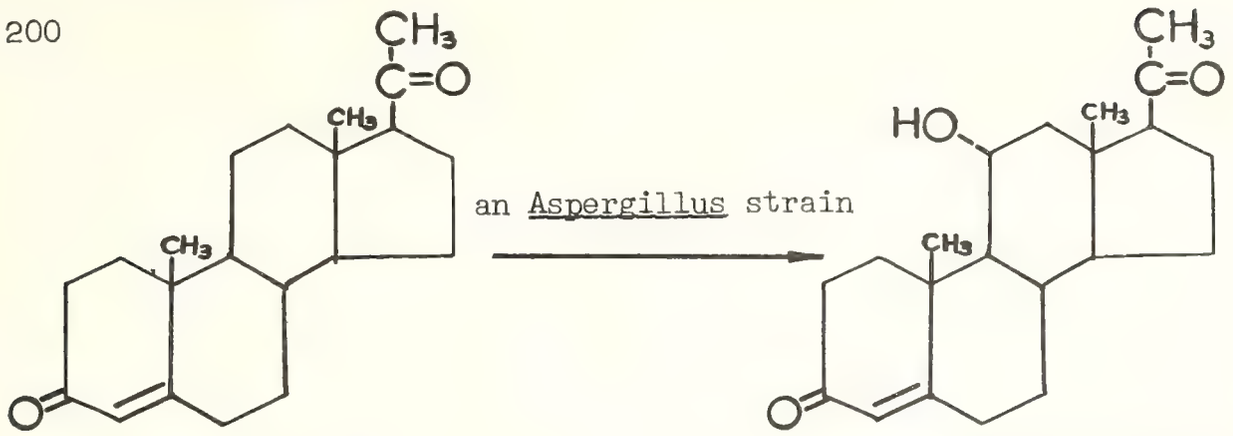


progesterone — 11α-hydroxyprogesterone (19%)

Weisz et al., Naturwissenschaften 43, 39-40 (1956).

C.A. 51, 14008d (1957).

Rx. 200

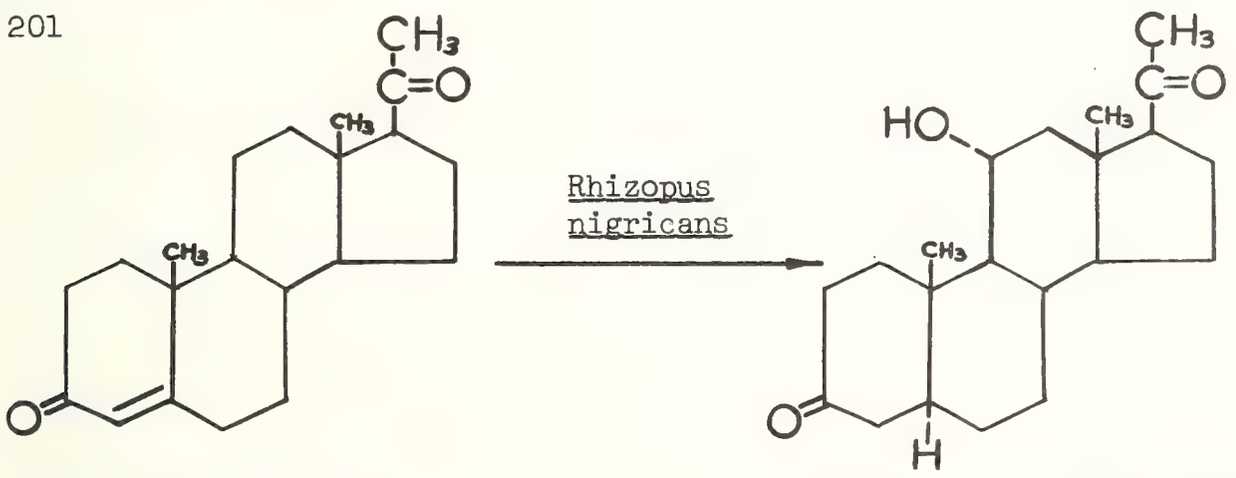


progesterone — 11α-hydroxyprogesterone

Peterson et al., J. Am. Chem. Soc. 74, 5933-6 (1952).

C.A. 47, 4426i (1953).

Rx. 201

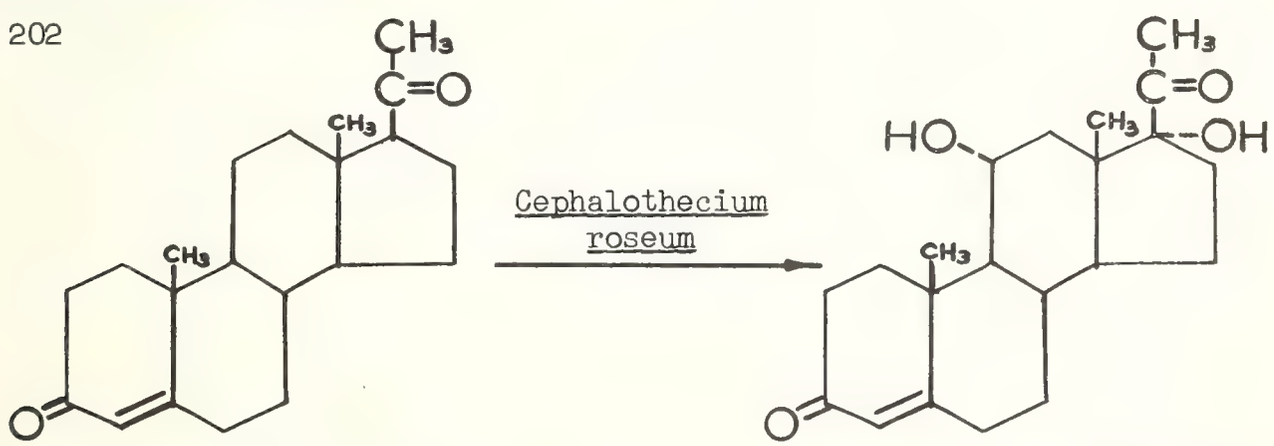


progesterone — 11α-hydroxyallopregnane-3, 20-dione (0.5-4.0%)

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 202

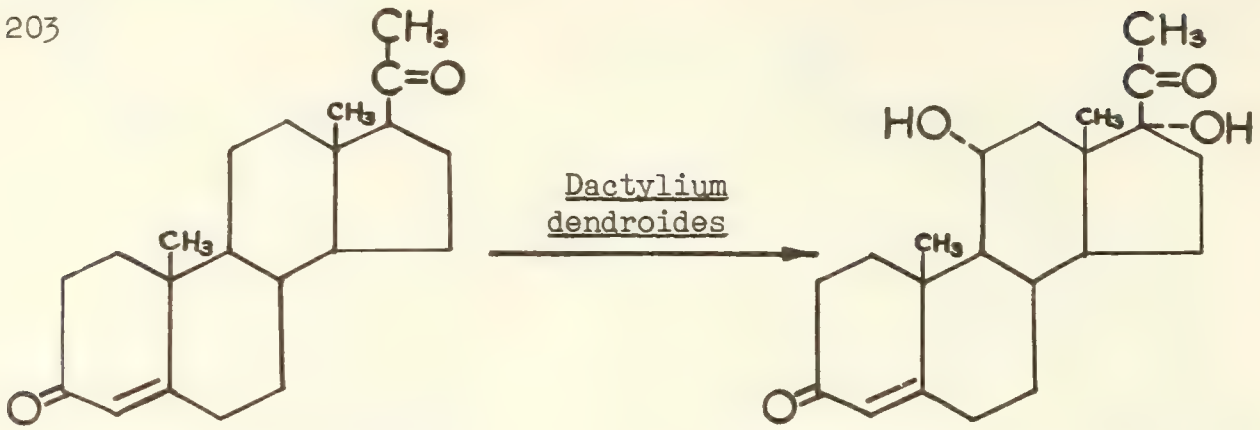


progesterone — 11α, 17α-dihydroxyprogesterone

Dulaney et al., Appl. Microbiol. 3, 372-4 (1955).

C.A. 50, 2741c (1956).

Rx. 203



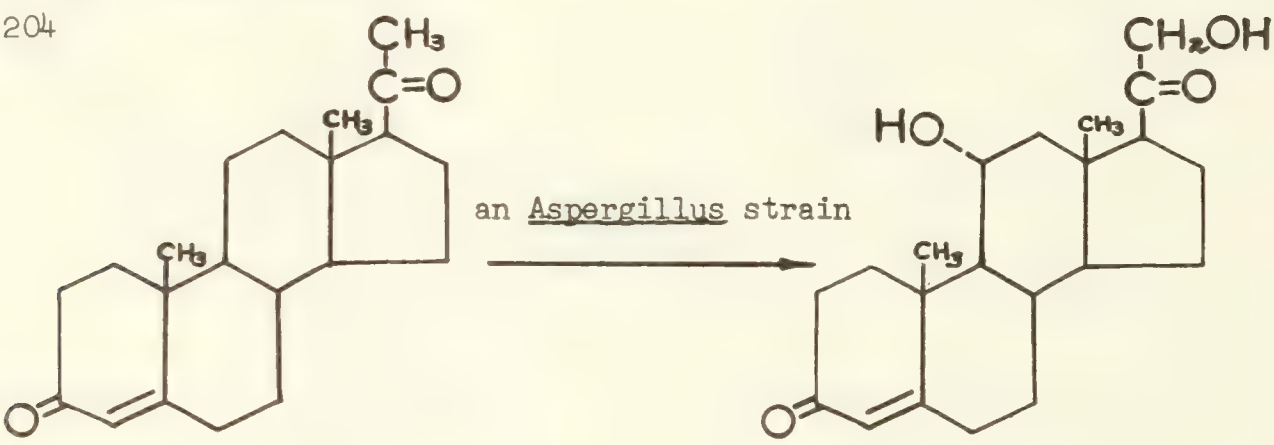
progesterone

11α, 17α-dihydroxyprogesterone
(15.4%)

Weisz et al., Naturwissenschaften 43, 39-40 (1956).

C.A. 51, 14008d (1957).

Rx. 204



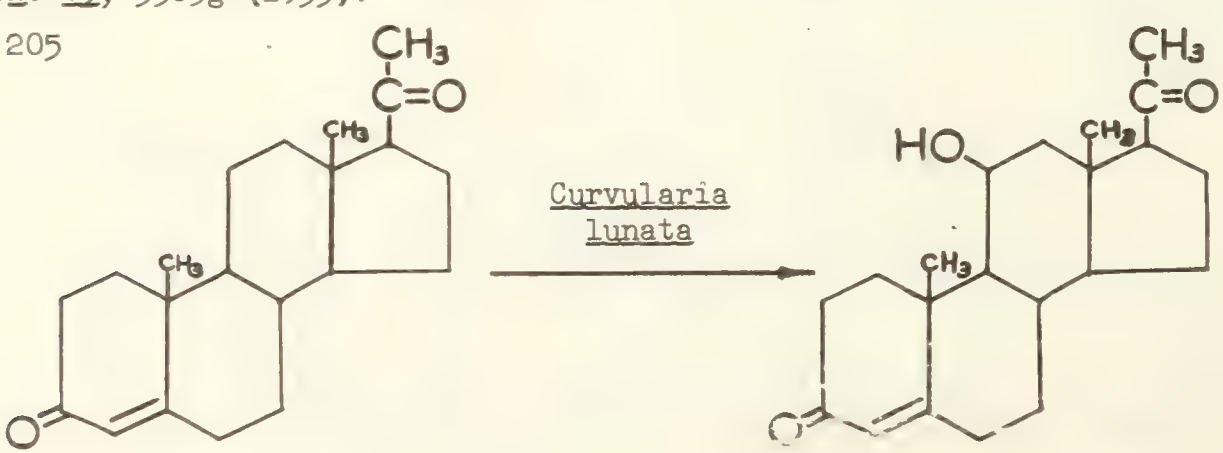
progesterone

11-epicorticosterone
(11α-hydroxycortexone)

Shull and Kita, J. Am. Chem. Soc. 77, 763-4 (1955).

C.A. 49, 5583g (1955).

Rx. 205

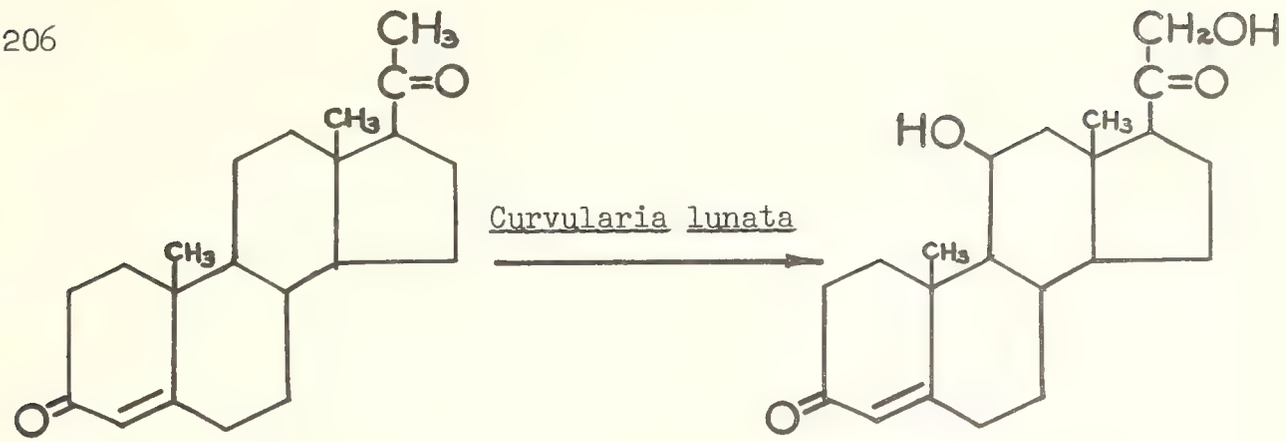


progesterone

11β-hydroxyprogesterone

Rubin et al., Bact. Proc., 33 (1956).

Rx. 206

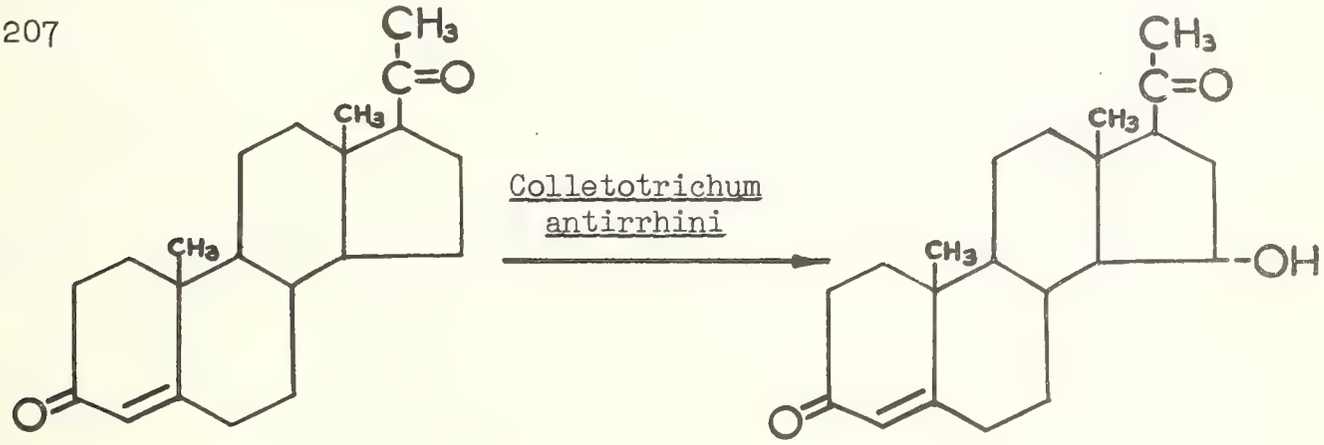


progesterone corticosterone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 207

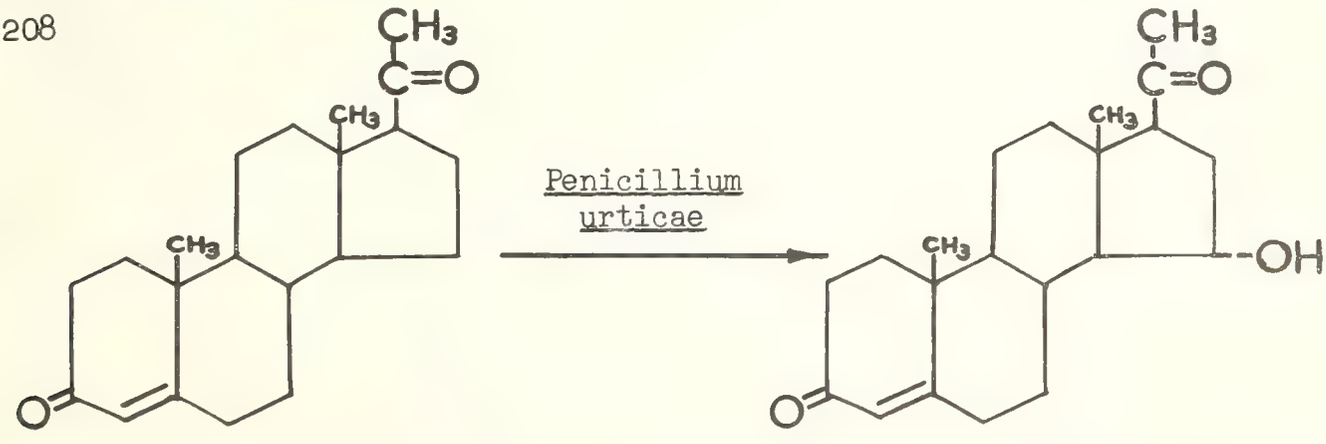


progesterone 15α-hydroxyprogesterone

Osborn et al., in Peterson, Record Chem. Progr. 17, 211-40 (1956).

C.A. 51, 3635c (1957).

Rx. 208

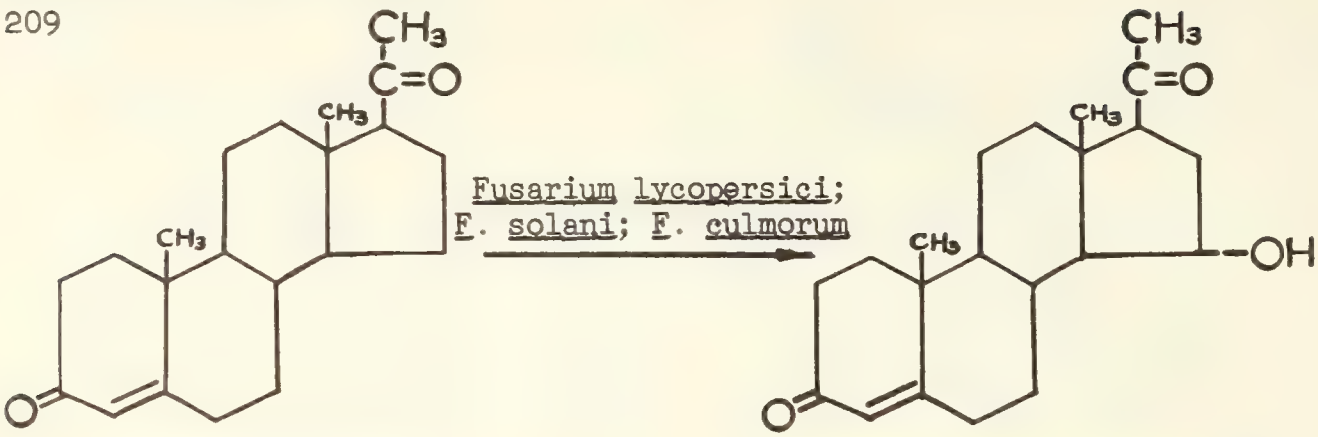


progesterone 15α-hydroxyprogesterone

Klüger et al., Naturwissenschaften 44, 40 (1957).

C.A. reference not available

Rx. 209

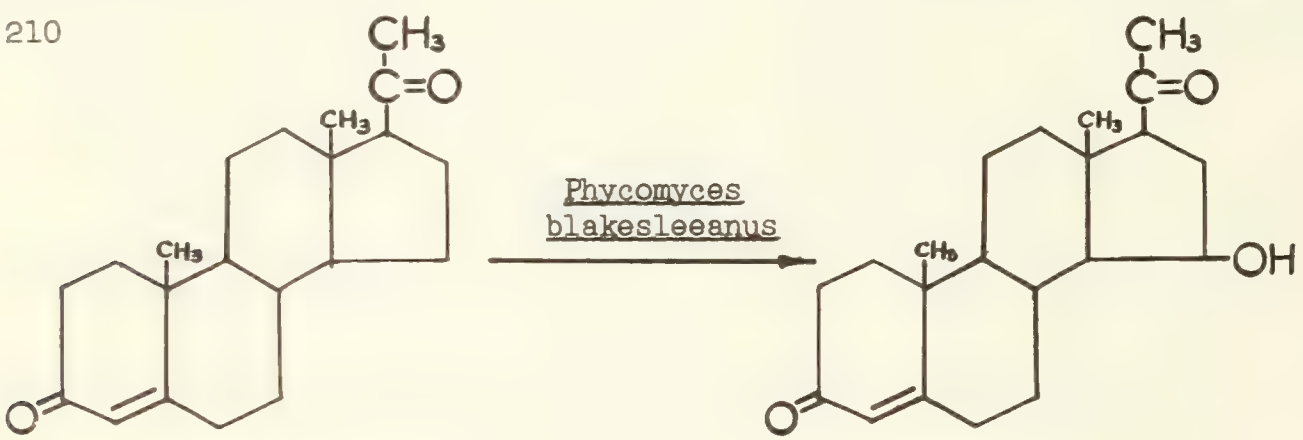


progesterone — 15α-hydroxyprogesterone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 210

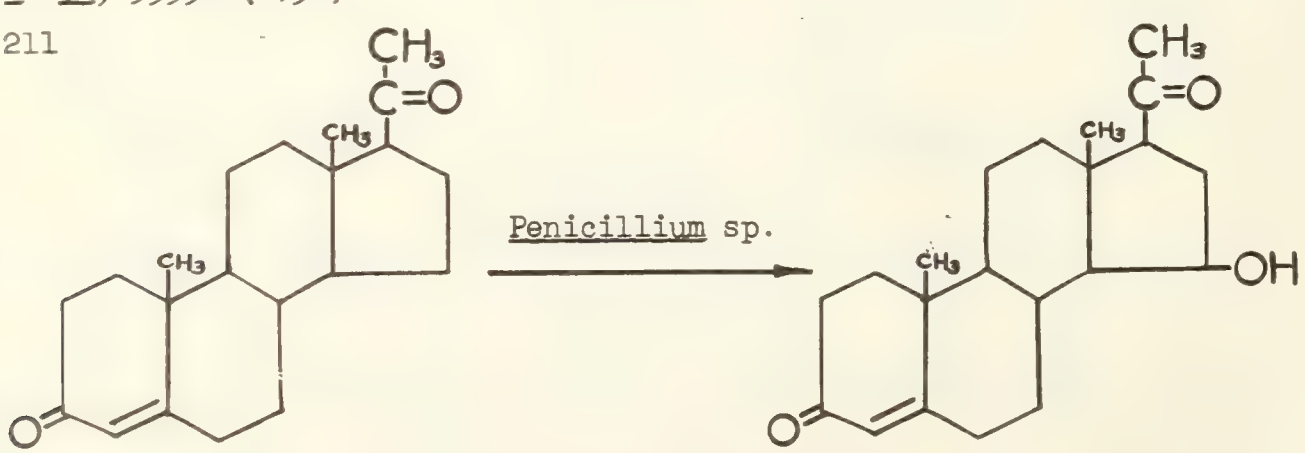


progesterone — 15β-hydroxyprogesterone

Dulaney et al., Appl. Microbiol. 3, 336-40 (1955).

C.A. 50, 3555e (1956).

Rx. 211

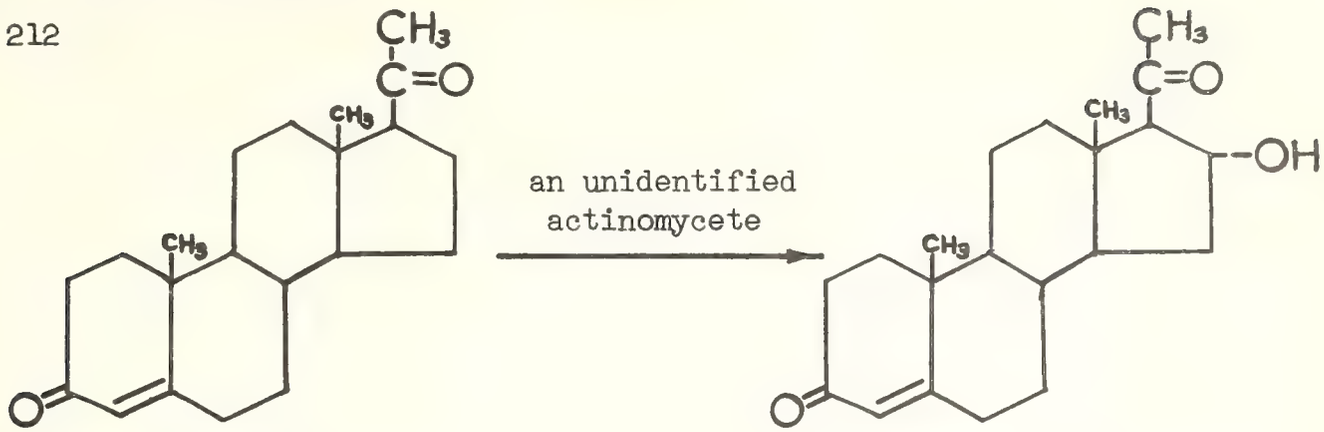


progesterone — possibly 15-hydroxyprogesterone

Perlman et al., J. Am. Chem. Soc. 74, 2126 (1952).

C.A. 48, 2737i (1954).

Rx. 212

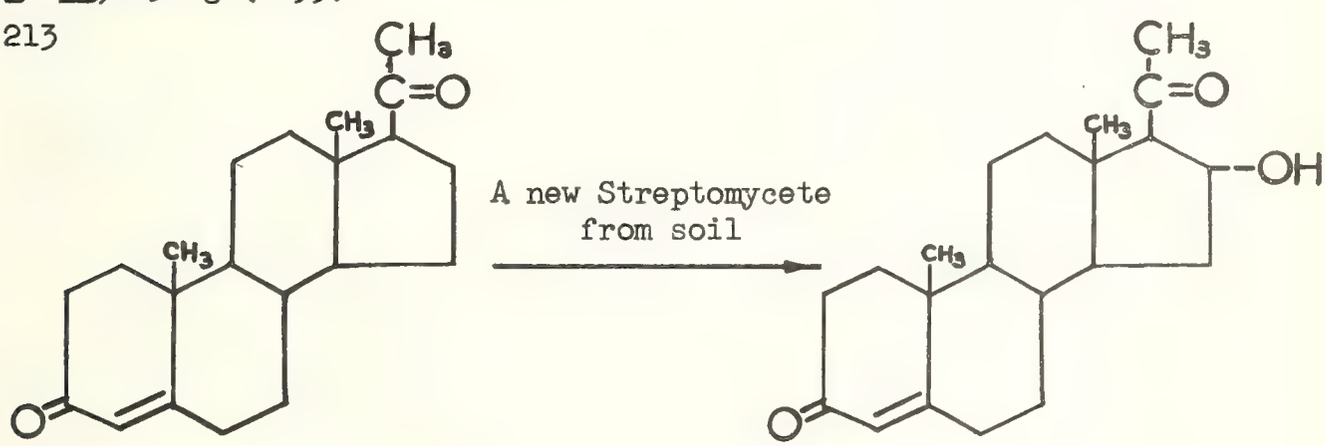


progesterone — 16α-hydroxyprogesterone

Perlman et al., J. Bacteriol. 69, 347-52 (1955).

C.A. 49, 8381g (1955).

Rx. 213

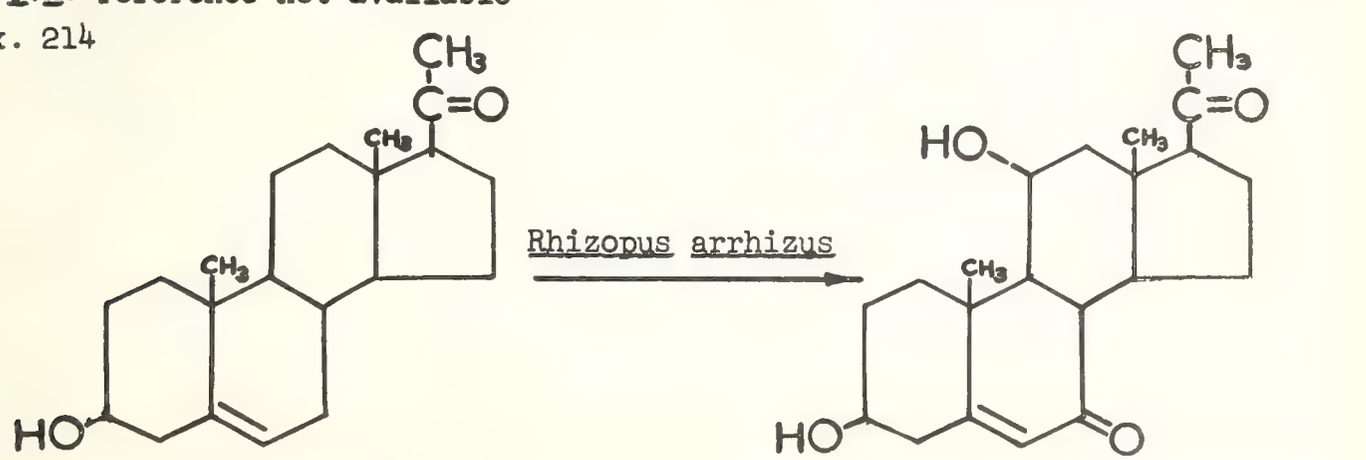


progesterone — 16α-hydroxyprogesterone

Murray and Peterson, Can. 506,689 (Oct. 19, 1954) (See U.S. 2,703,326 (Mar. 1, 1955) in C.A. 50, 1937b.)

C.A. reference not available

Rx. 214

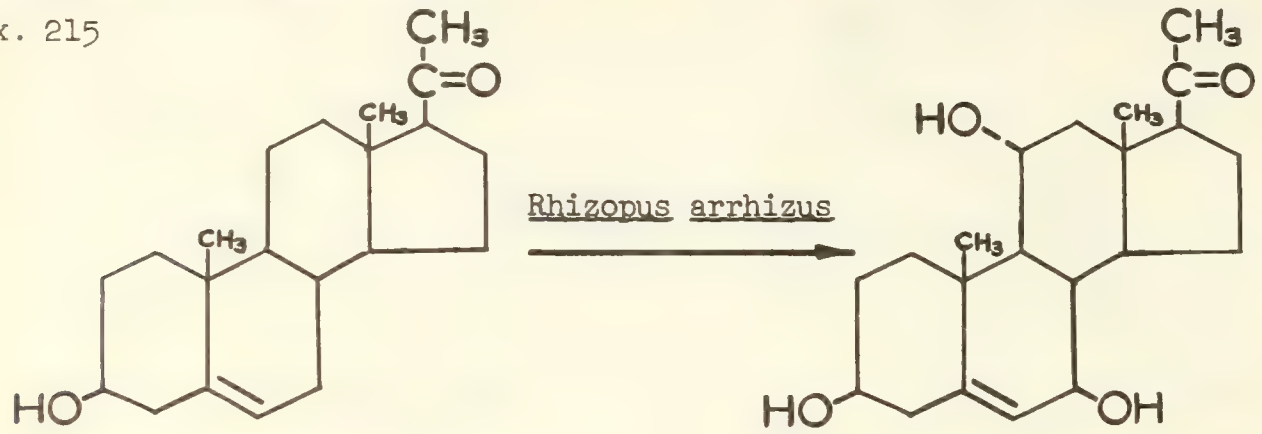


3β-hydroxy-Δ^5-pregnene-20-one (pregnenolone) — Δ^5-pregnene-3β,11α-diol-7,20-dione (17.5%)

Murray and Peterson, Can. 506,689 (Oct. 19, 1954). (See U.S. 2,702,809 (Feb. 22, 1955); C.A. 50, 2690i.)

C.A. reference not available

Rx. 215



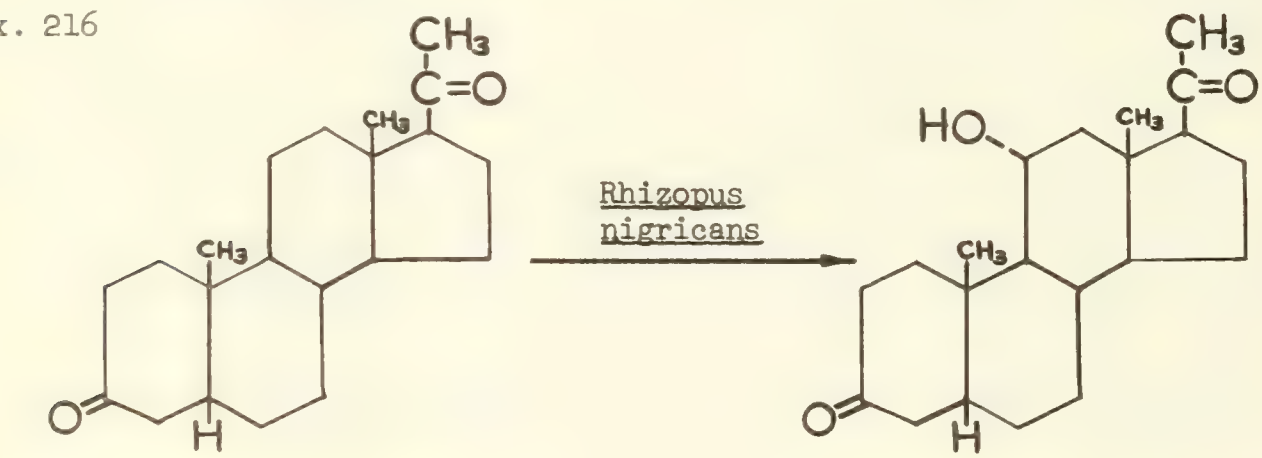
3β-hydroxy-Δ^5-pregnene-20-one

3β,7,11α-trihydroxy-Δ^5-pregnene-20-one (17%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 216



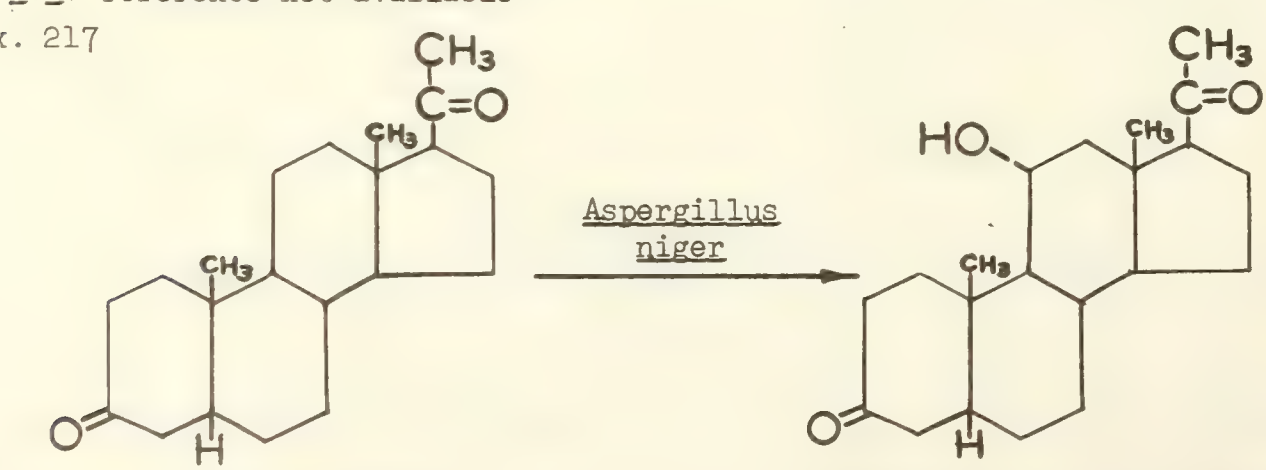
pregnane-3,20-dione

11α-hydroxypregnane-3,20-dione (40%)

Murray and Peterson, U.S. 2,649,402 (Aug. 18, 1953).

C.A. reference not available

Rx. 217



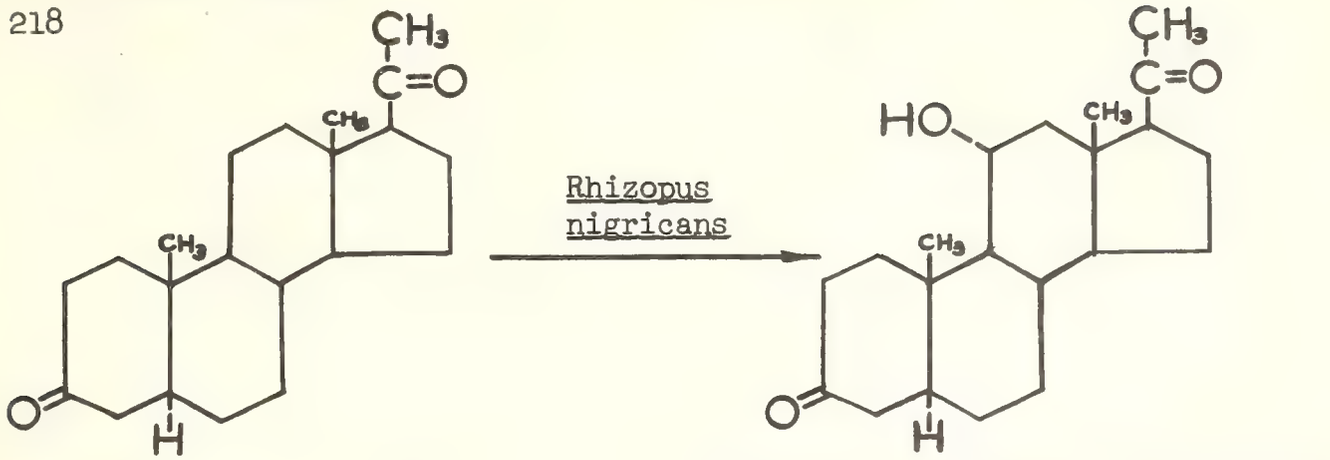
pregnane-3,20-dione

11α-hydroxypregnane-3,20-dione

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 218



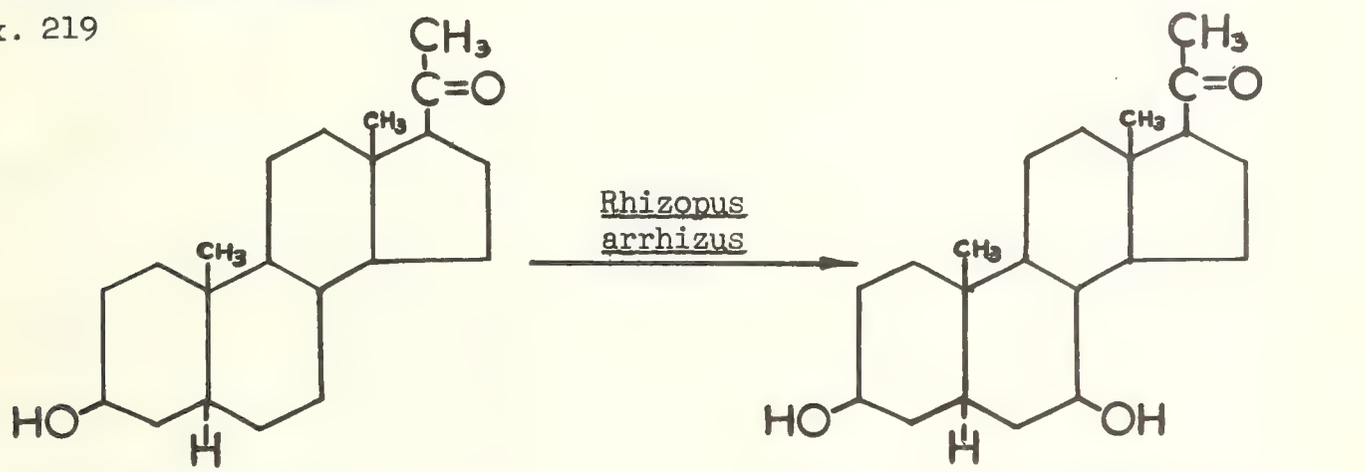
allopregnane-3,20-dione

11α-hydroxyallopregnane-3,20-dione

Murray and Peterson, U.S. 2,602,769 (July 8, 1952). (See Peterson, Record Chem. Progr. 17, 214 (1956).)

C.A. 46, 8331f (1952).

Rx. 219



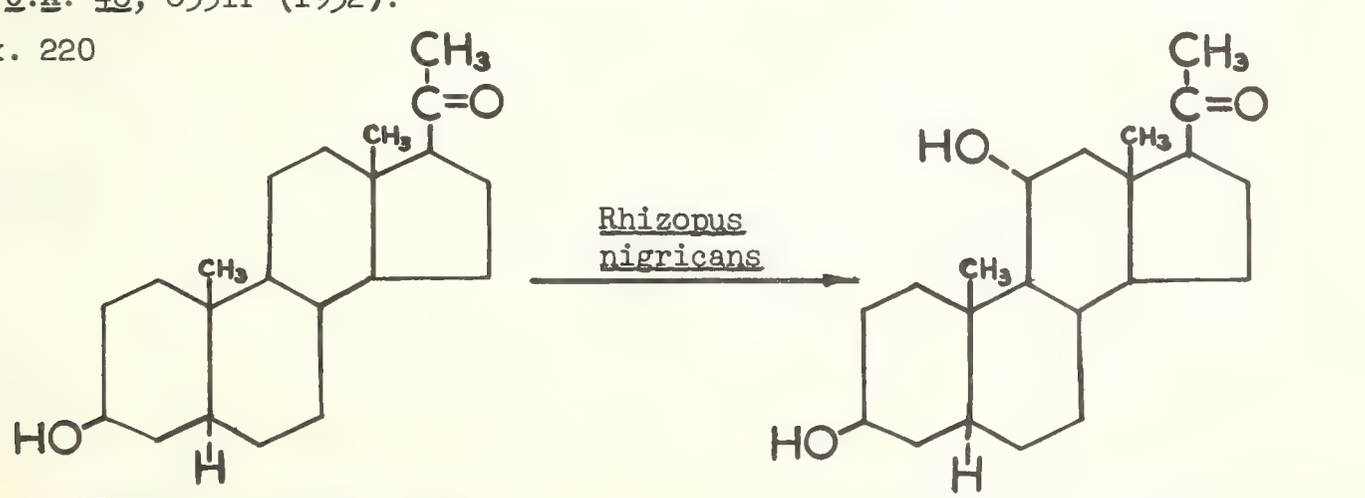
allopregnane-3β-ol-20-one

3β,7-dihydroxyallopregnane-20-one
(5.2%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 220



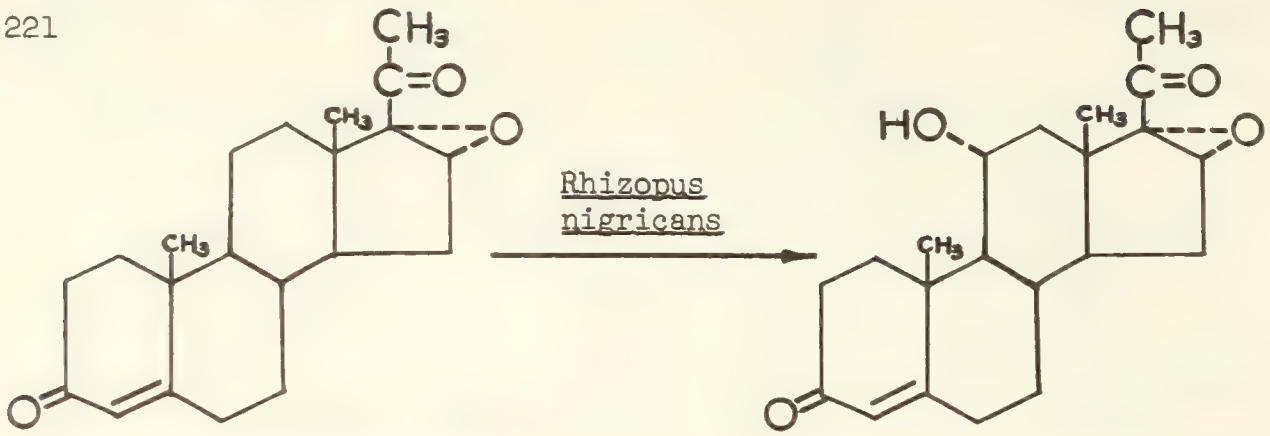
allopregnane-3β-ol-20-one

3β,11α-dihydroxyallopregnane-20-one
(23%)

Ercoli et al., Gazz. chim. ital. 85, 628-38 (1955).

C.A. 50, 5001b (1956).

Rx. 221



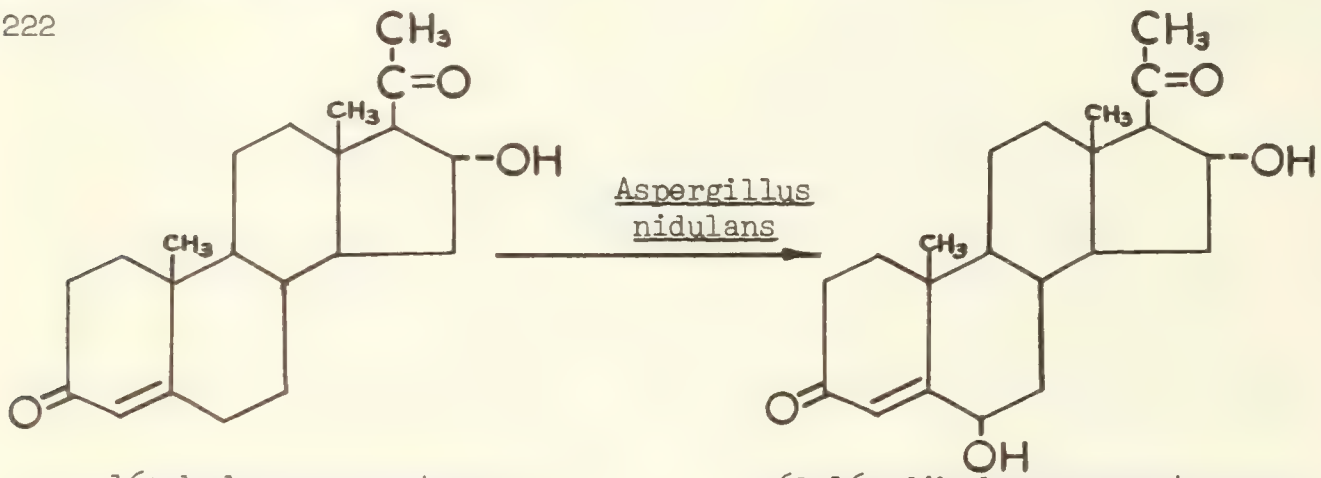
16α,17α-oxidoprogesterone

11α-hydroxy-16α,17α-oxido-progesterone (80%)

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 222



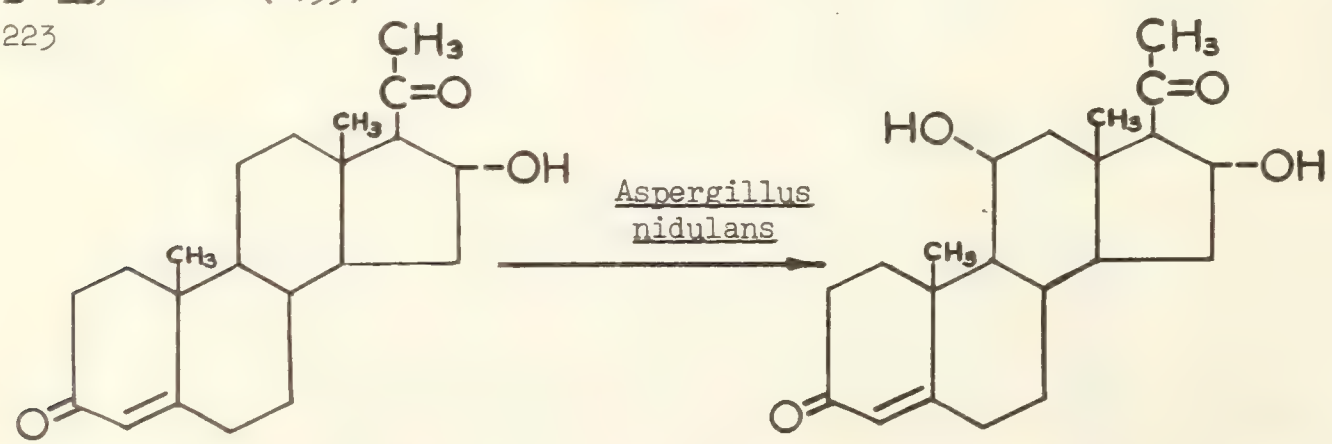
16α-hydroxyprogesterone

6β,16α-dihydroxyprogesterone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 223



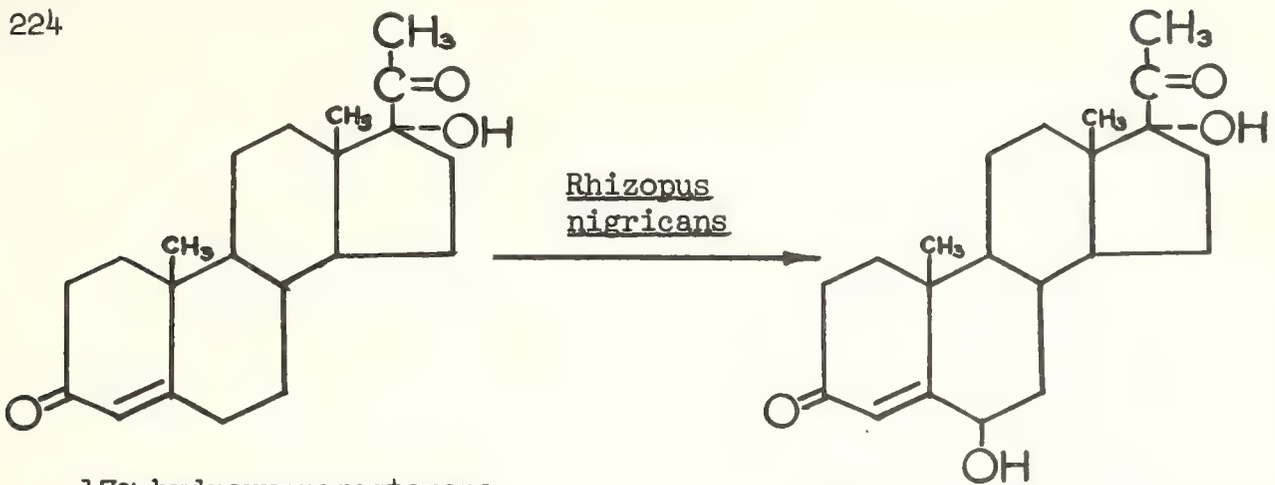
16α-hydroxyprogesterone

11α,16α-dihydroxyprogesterone (45%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 224



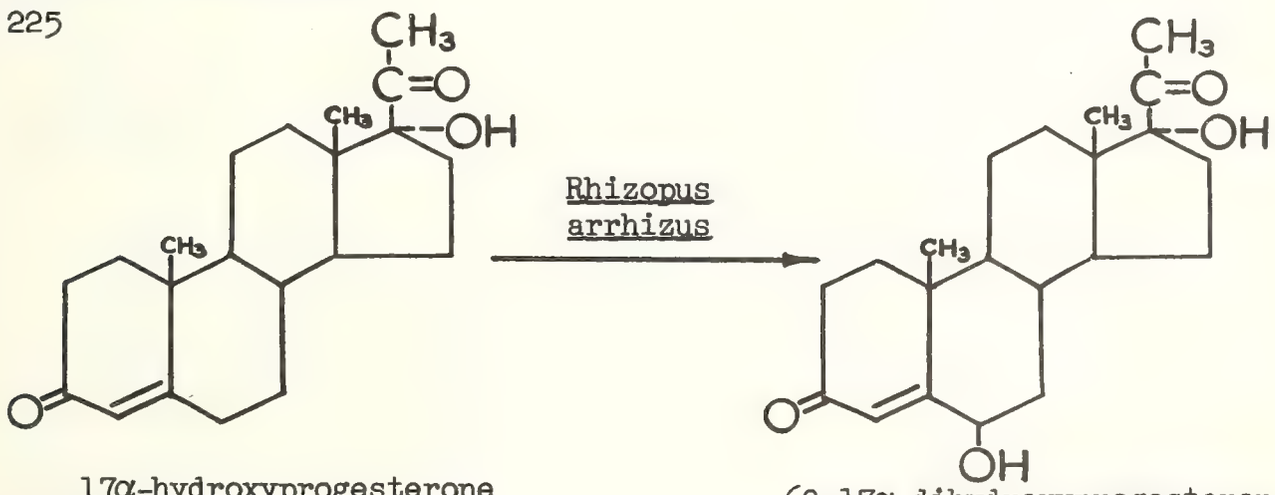
17α-hydroxyprogesterone

6,17α-dihydroxyprogesterone
(approx. 1%)

Meister et al., J. Am. Chem. Soc. 75, 416-18 (1953).

C.A. 48, 2753d (1954).

Rx. 225



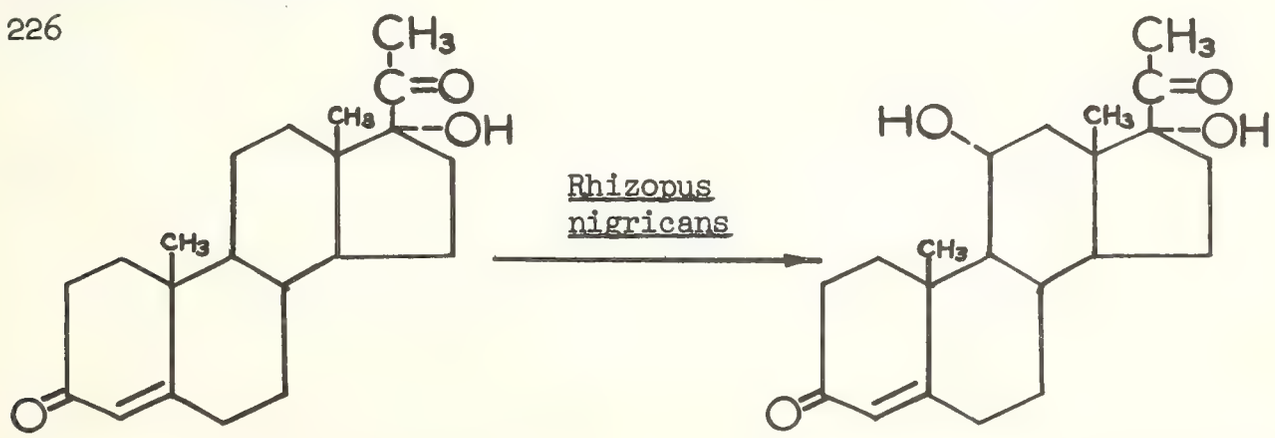
17α-hydroxyprogesterone

6β,17α-dihydroxyprogesterone
(45%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 226



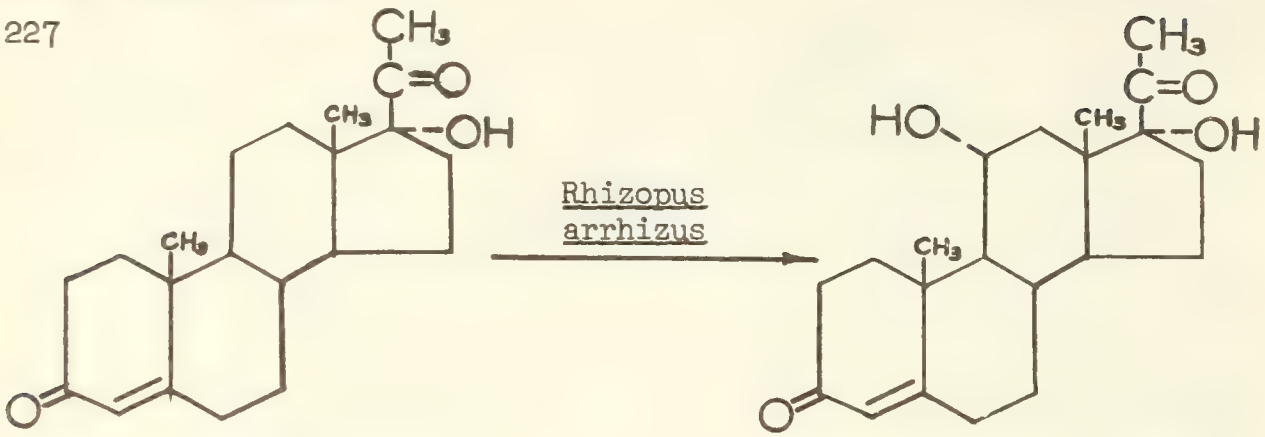
17α-hydroxyprogesterone

11α,17α-dihydroxyprogesterone
(17%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 227



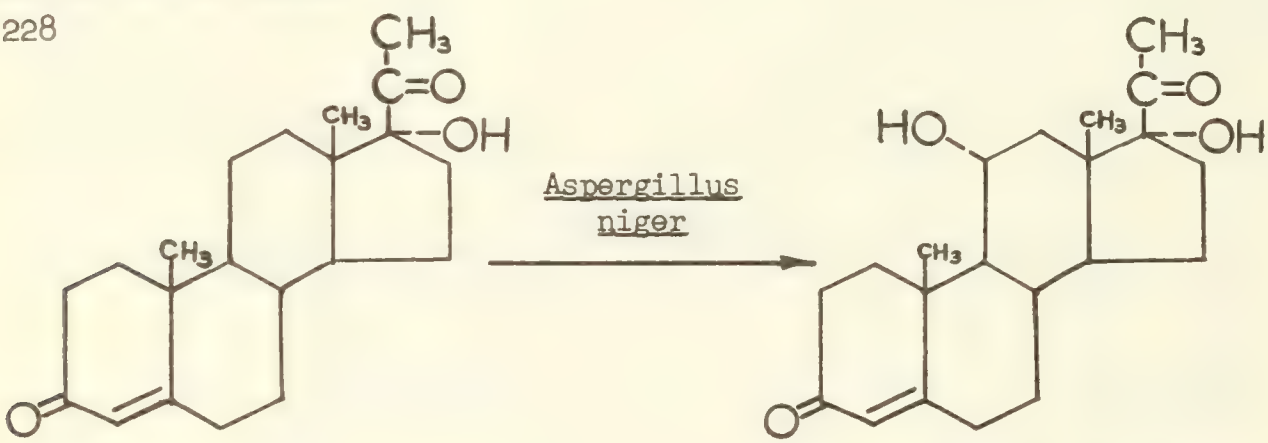
17α-hydroxyprogesterone

11α,17α-dihydroxyprogesterone
(approx. 2%)

Fried et al., J. Am. Chem. Soc. 74, 3962-3 (1952).

C.A. 48, 5874a (1954).

Rx. 228



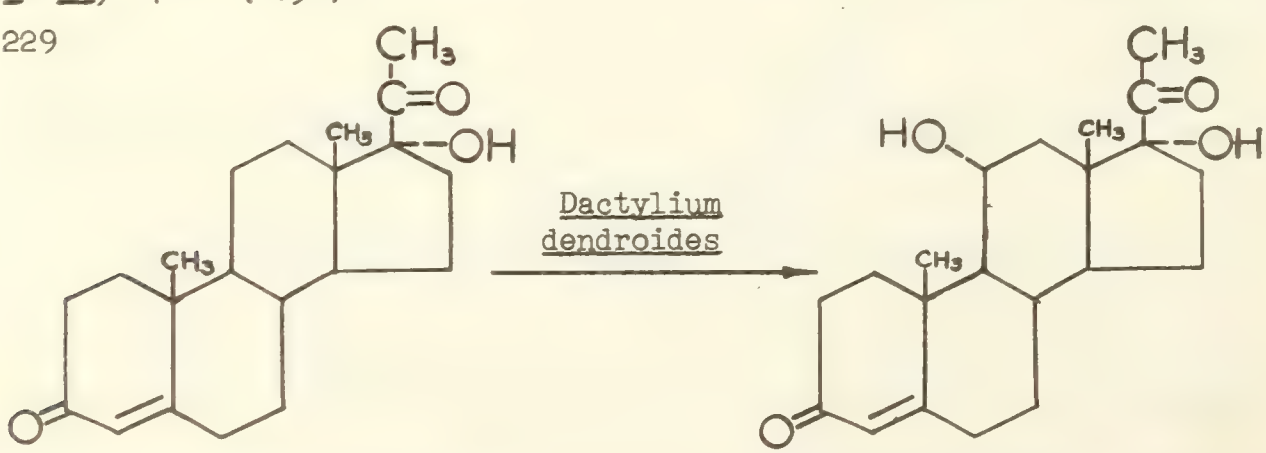
17α-hydroxyprogesterone

11α,17α-dihydroxyprogesterone
(15%)

Dulaney et al., Appl. Microbiol. 3, 372-4 (1955).

C.A. 50, 2741c (1956).

Rx. 229



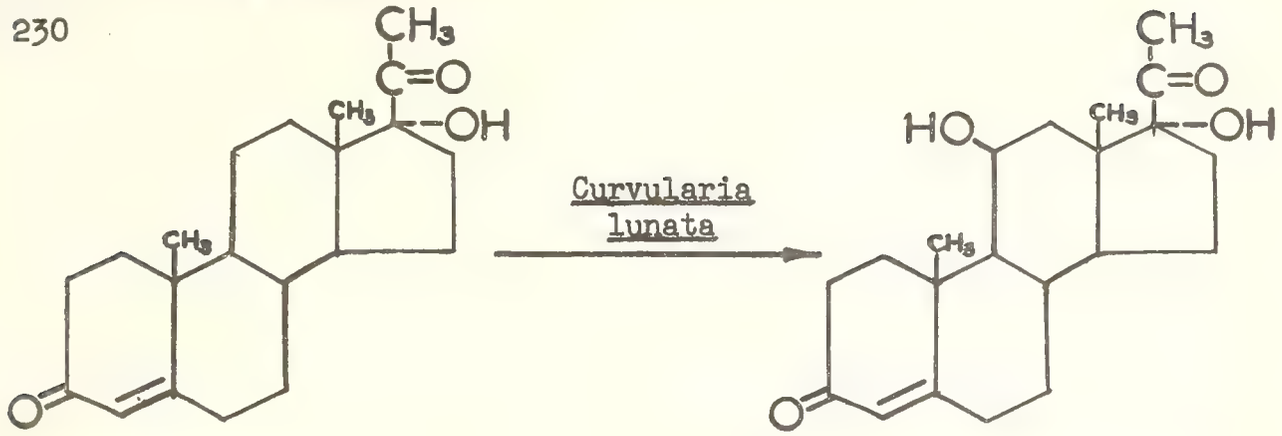
17α-hydroxyprogesterone

11α,17α-dihydroxyprogesterone
(27%)

Shull and Kita, J. Am. Chem. Soc. 77, 763-4 (1955).

C.A. 49, 5583g (1955).

Rx. 230



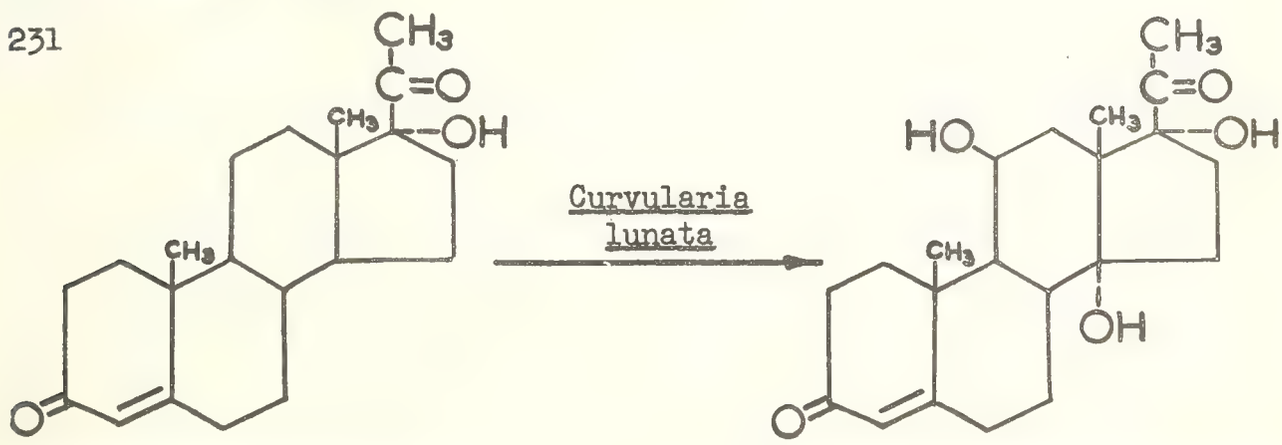
17α-hydroxyprogesterone

11β,17α-dihydroxyprogesterone
(approx. 30%)

Shull et al., U.S. 2,702,812 (Feb. 22, 1955).

C.A. 50, 2689i (1956).

Rx. 231



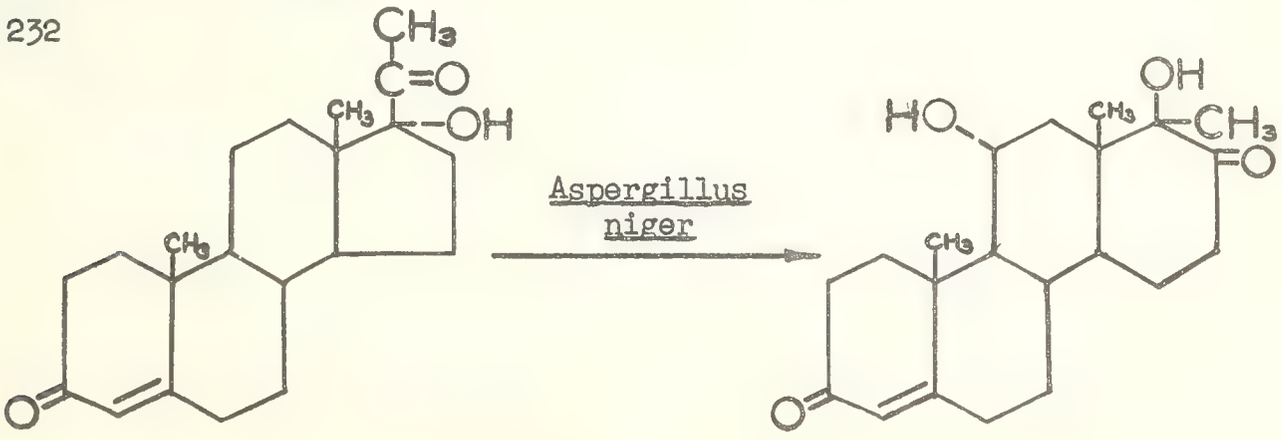
17α-hydroxyprogesterone

11β,14α,17α-trihydroxyprogesterone
(20%)

Fried et al., J. Am. Chem. Soc. 74, 3962-3 (1952).

C.A. 48, 5874a (1954).

Rx. 232



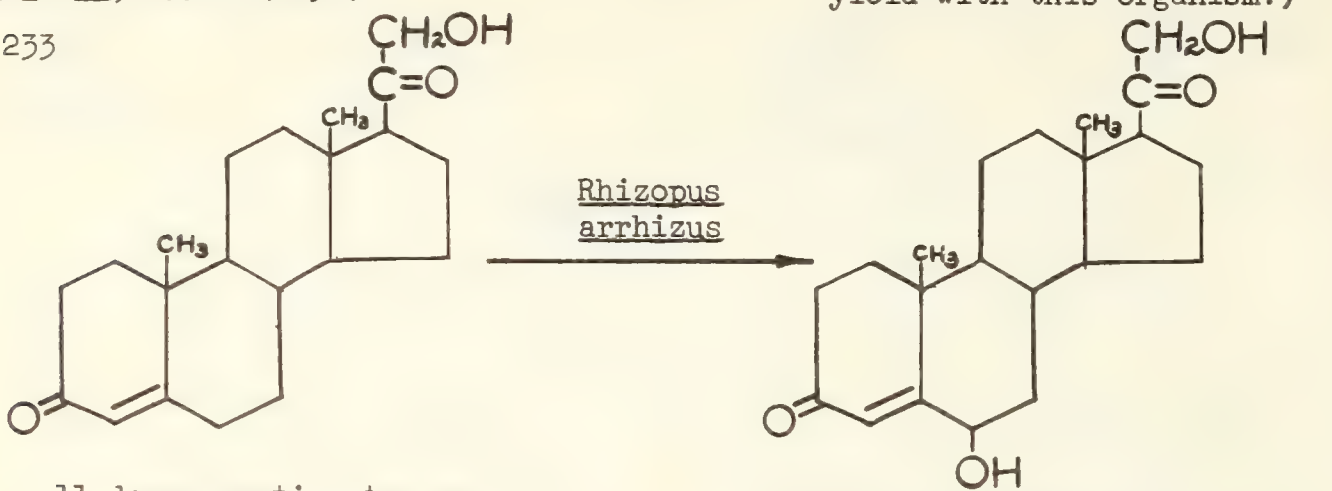
17α-hydroxyprogesterone

17a-methyl-D-homo-Δ^4-androstene-
11α,17a-diol-3,17-dione (25%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952). (See U.S. 2,703,327 (Mar. 1, 1955) for higher yield with this organism.)

C.A. 46, 8331f (1952).

Rx. 233



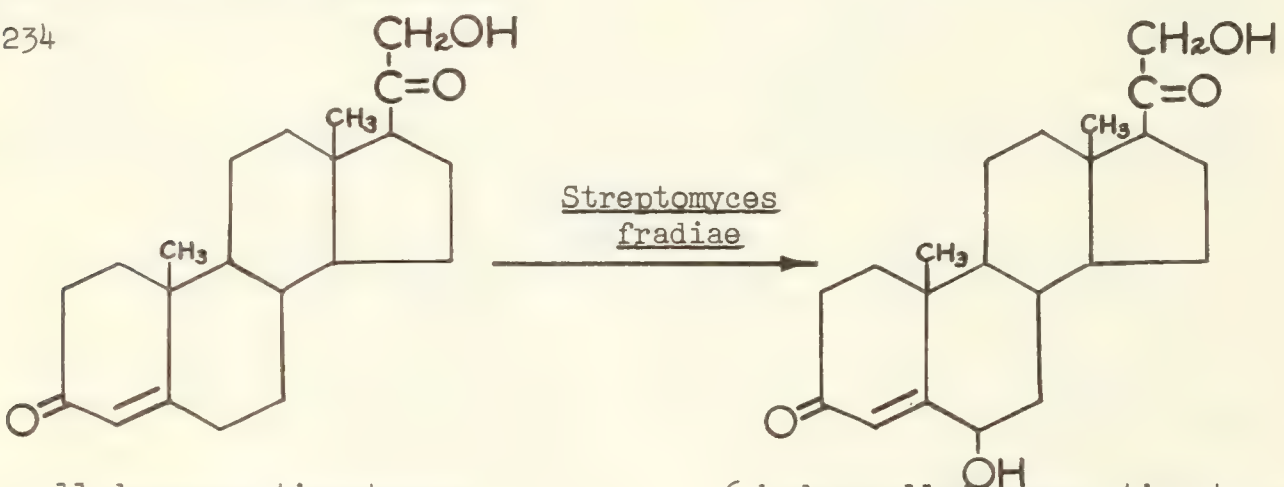
11-desoxycorticosterone (cortexone)

6-hydroxy-11-desoxycorticosterone (approx. 0.7%)

Haines and Colingsworth, U.S. 2,649,401 (Aug. 18, 1953).

C.A. reference not available

Rx. 234



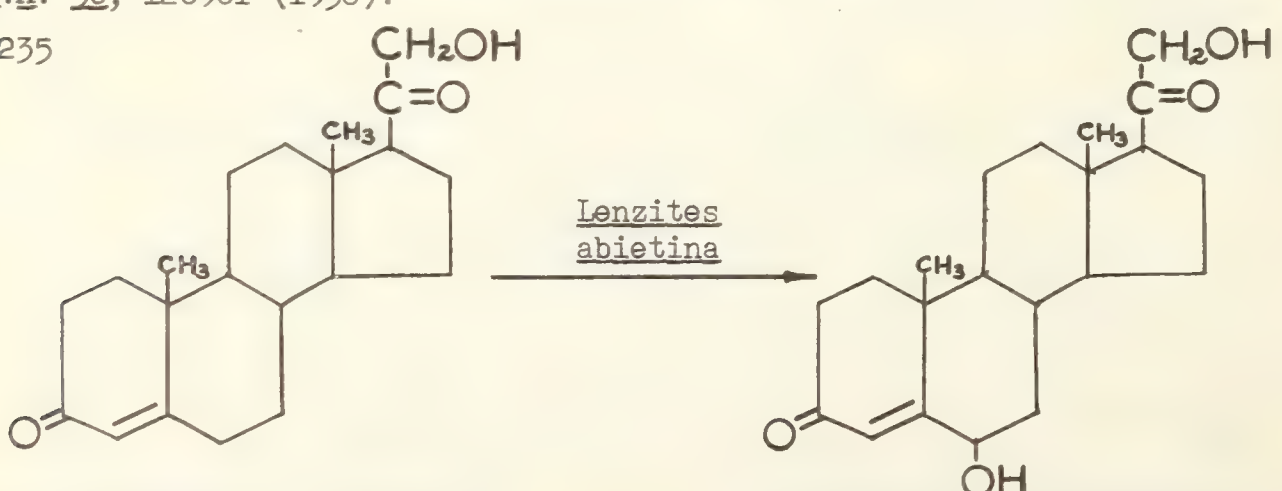
11-desoxycorticosterone

6-hydroxy-11-desoxycorticosterone

Meystre et al., Helv. Chim. Acta 38, 381-93 (1955).

C.A. 50, 12090i (1956).

Rx. 235



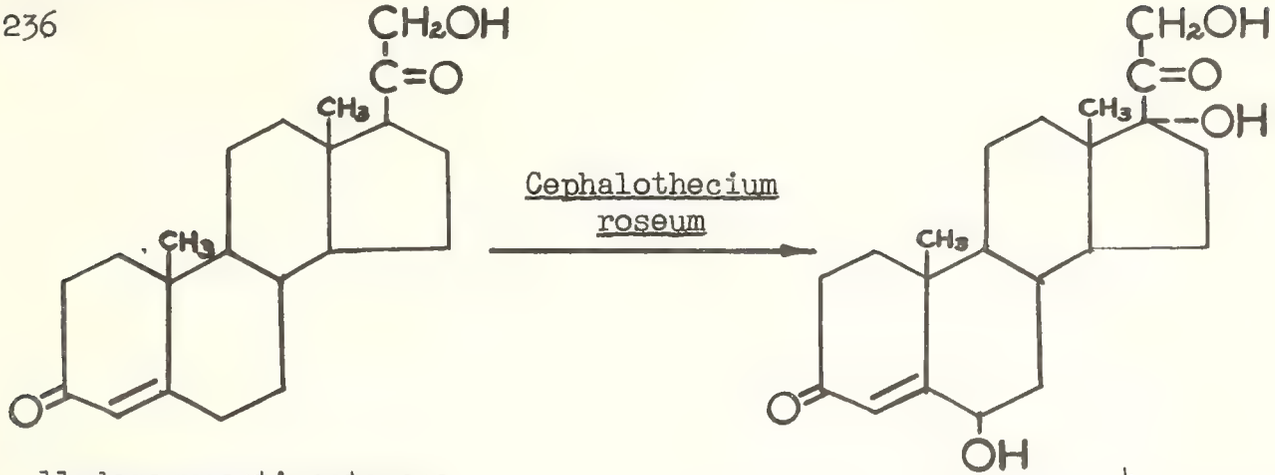
11-desoxycorticosterone

6β-hydroxy-11-desoxycorticosterone (4.8%)

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 236



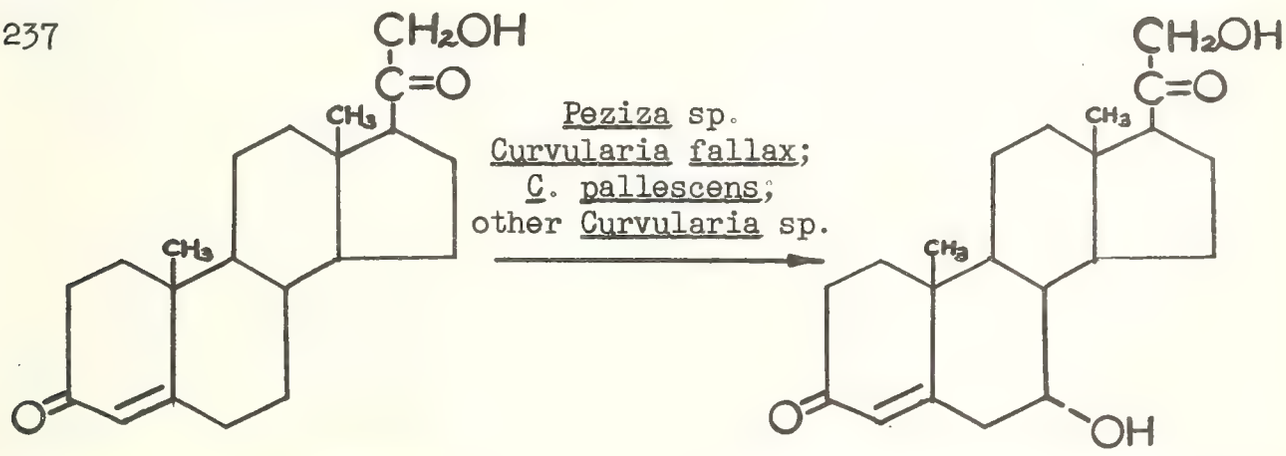
11-desoxycorticosterone (cortexone)

6β,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione

Meystre et al., Helv. Chim. Acta 38, 381-93 (1955).

C.A. 50, 12090i (1956).

Rx. 237



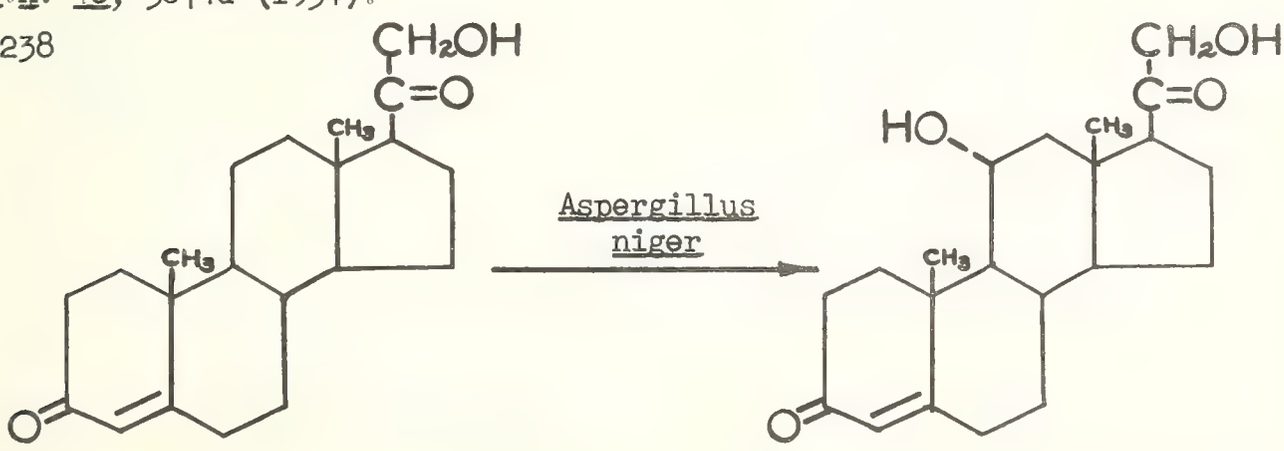
11-desoxycorticosterone

7α-hydroxy-11-desoxycorticosterone (50-60%)

Fried et al., J. Am. Chem. Soc. 74, 3962-3 (1952).

C.A. 48, 5874a (1954).

Rx. 238



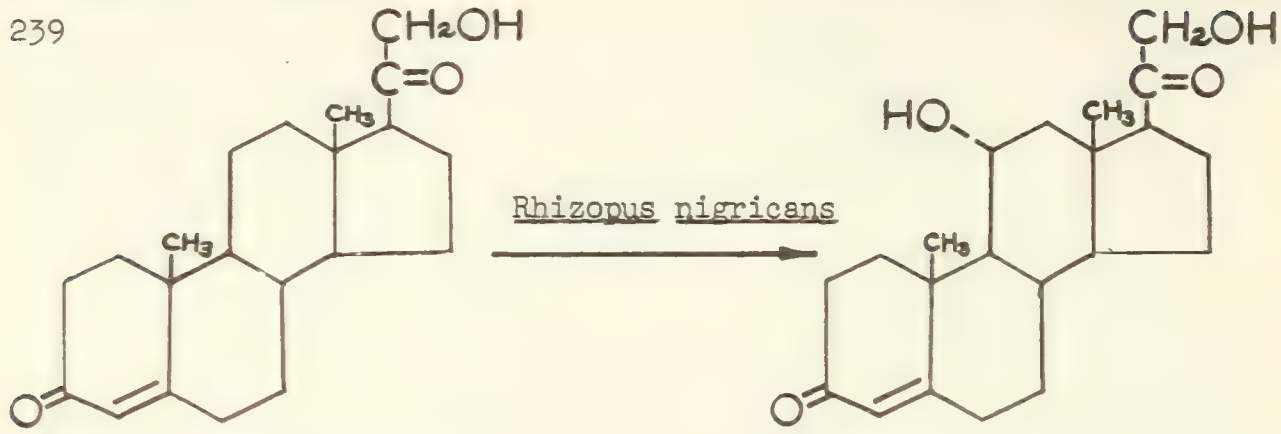
11-desoxycorticosterone

Δ^4-pregnene-11α,21-diol-3,20-dione (epicorticosterone) (67%)

Eppstein et al., J. Am. Chem. Soc. 75, 408-12 (1953).

C.A. 48, 2751i (1954).

Rx. 239



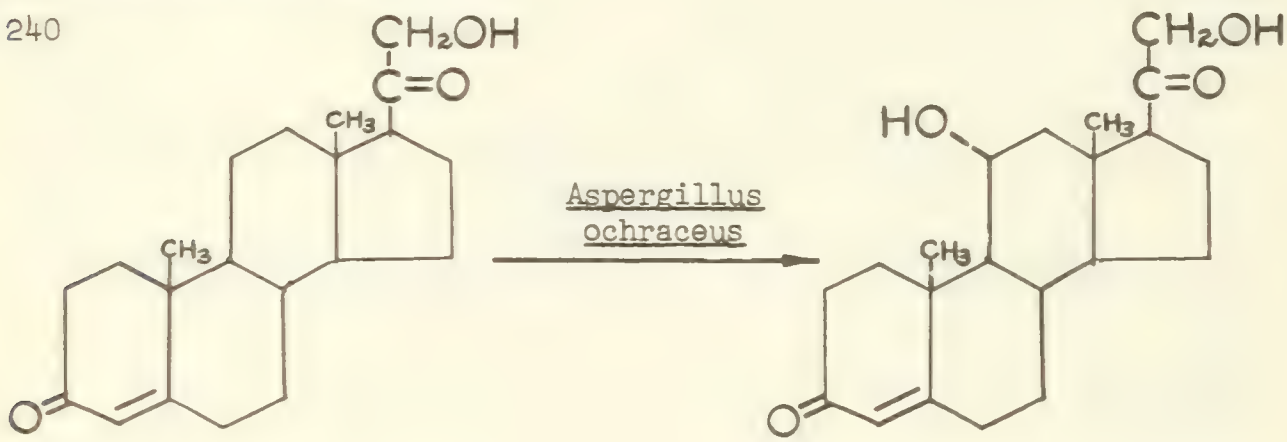
11-desoxycorticosterone

Δ^4-pregnene-11α,21-diol-3,20-dione (50-60%) (epicorticosterone)

Dulaney et al., Mycologia 47, 464-74 (1955).

C.A. reference not available

Rx. 240



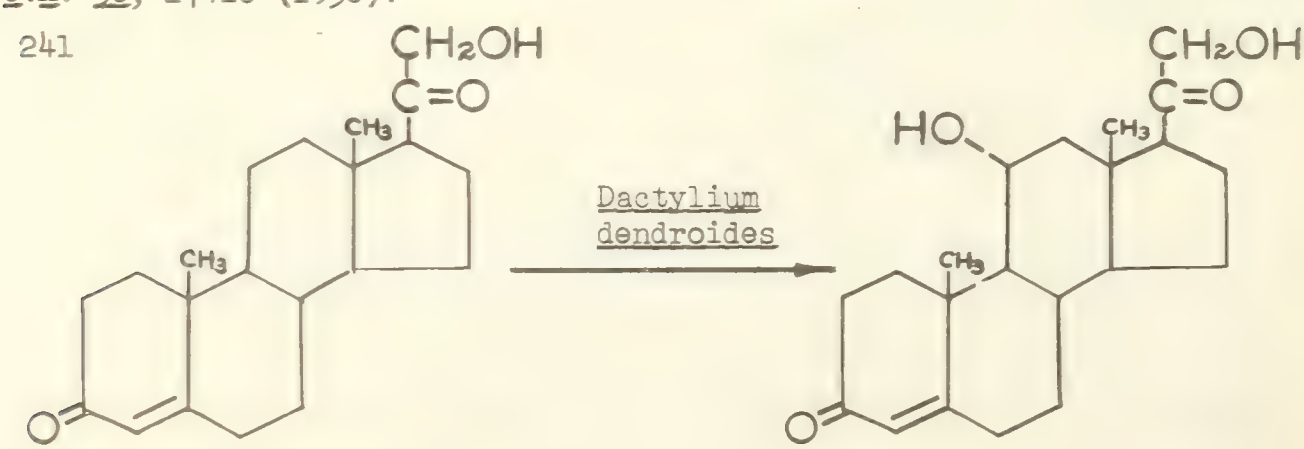
11-desoxycorticosterone

Δ^4-pregnene-11α,21-diol-3,20-dione (75%)

Dulaney et al., Appl. Microbiol. 3, 372-4 (1955).

C.A. 50, 2741c (1956).

Rx. 241



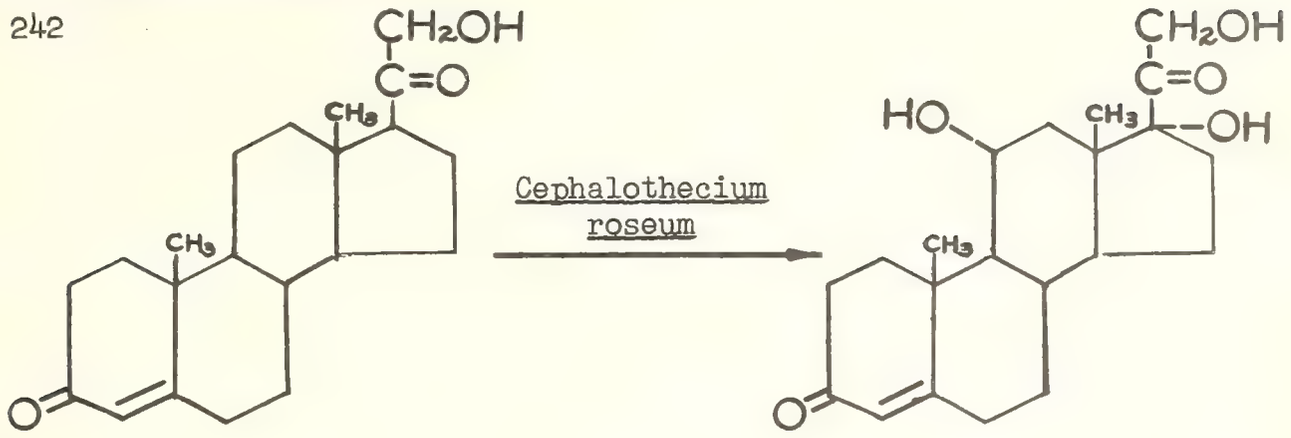
11-desoxycorticosterone

Δ^4-pregnene-11α,21-diol-3,20-dione

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 242



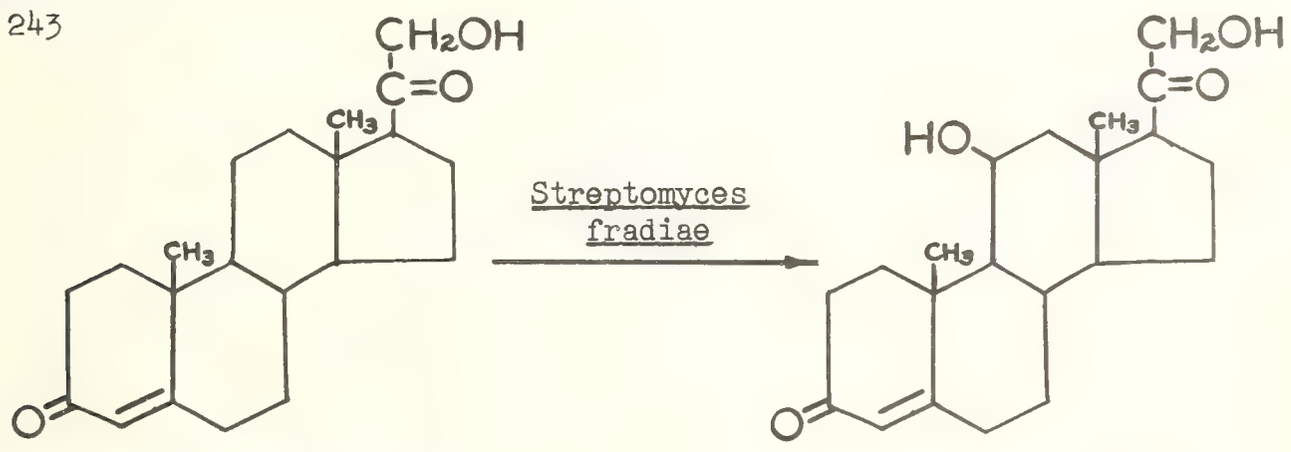
11-desoxycorticosterone (cortexone)

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione

Colingsworth et al., J. Am. Chem. Soc. 74, 2381-2 (1952).

C.A. 48, 2751d (1954).

Rx. 243



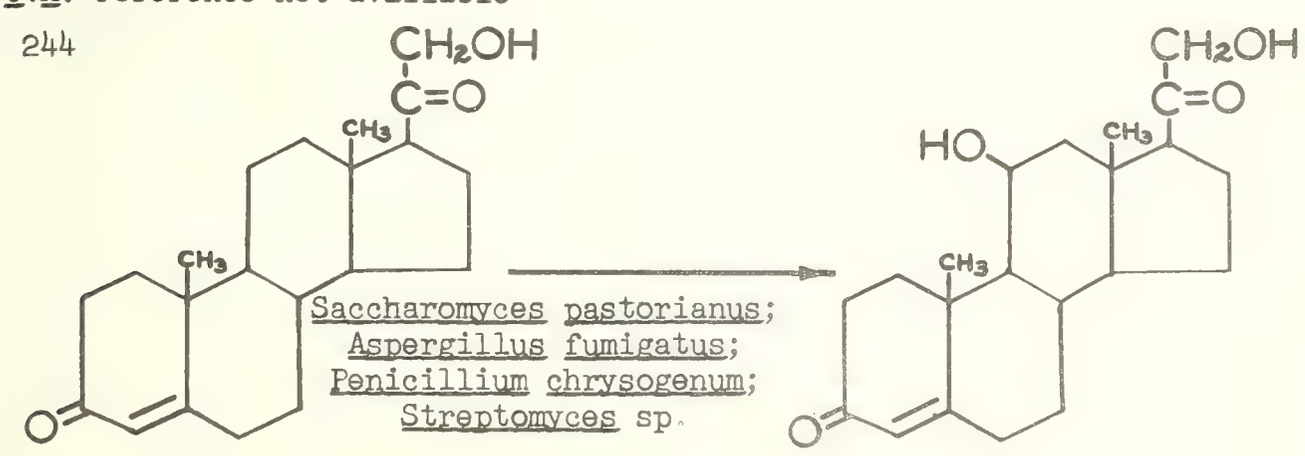
11-desoxycorticosterone

corticosterone (approx. 6%)

Haines and Colingsworth, U.S. 2,649,401 (Aug. 18, 1953).

C.A. reference not available

Rx. 244



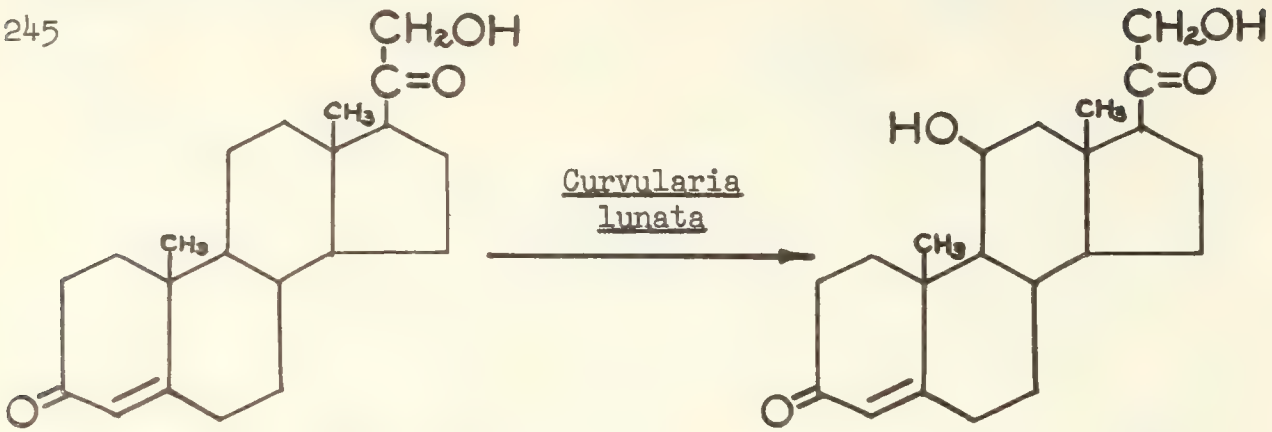
11-desoxycorticosterone

corticosterone (1.5-2.0%)

Shull et al., U.S. 2,658,023 (Nov. 3, 1953).

C.A. 48, 2332h (1954).

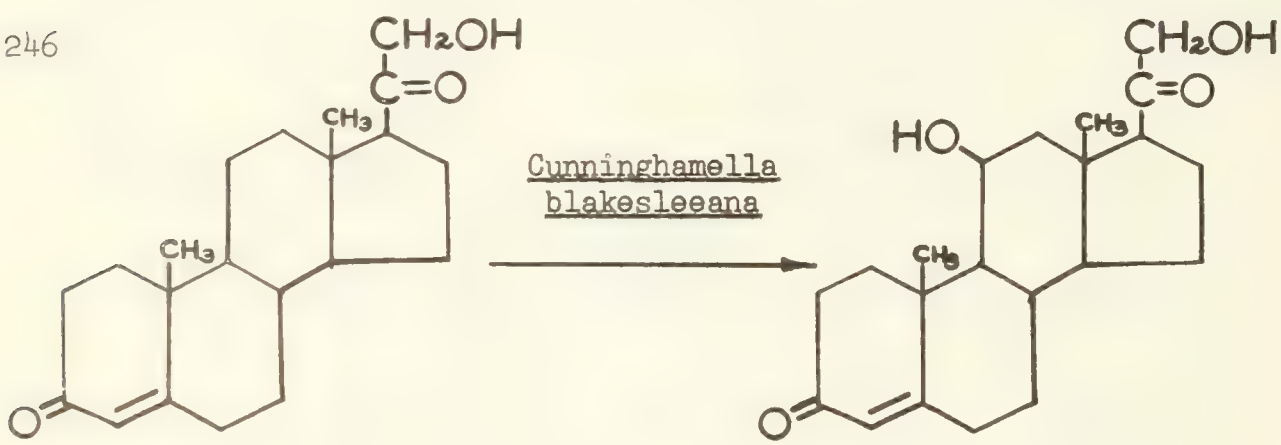
Rx. 245



11-desoxycorticosterone — corticosterone (28%)

Mann et al., Federation Proc. 14, 251 (1955).

Rx. 246

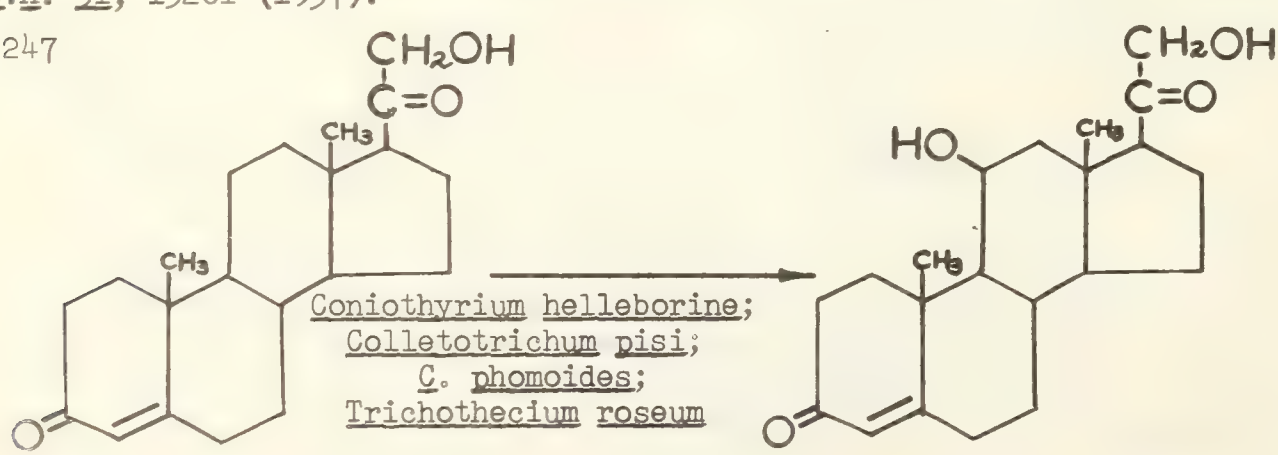


11-desoxycorticosterone — corticosterone

Olin Mathieson Chemical Corp., Brit. 749,414 (May 23, 1956).

C.A. 51, 1320i (1957).

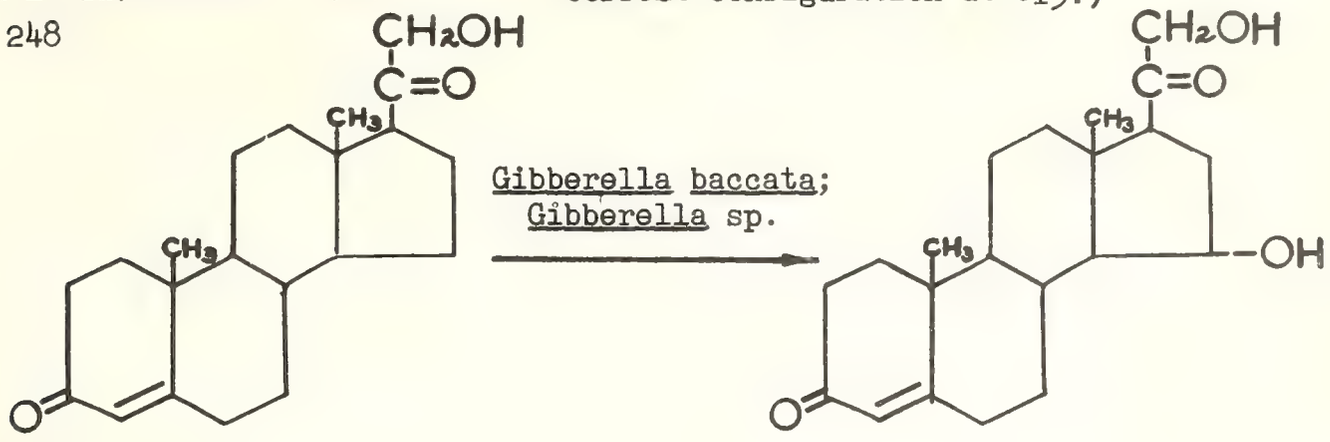
Rx. 247



11-desoxycorticosterone — corticosterone

Meystre et al., Helv. Chim. Acta 38, 381-93 (1955). (See D. H. Peterson, Record Chem. Prog. 17, p. 217 (1956) for correct configuration at C_{15}.)
C.A. 50, 12090i (1956).

Rx. 248

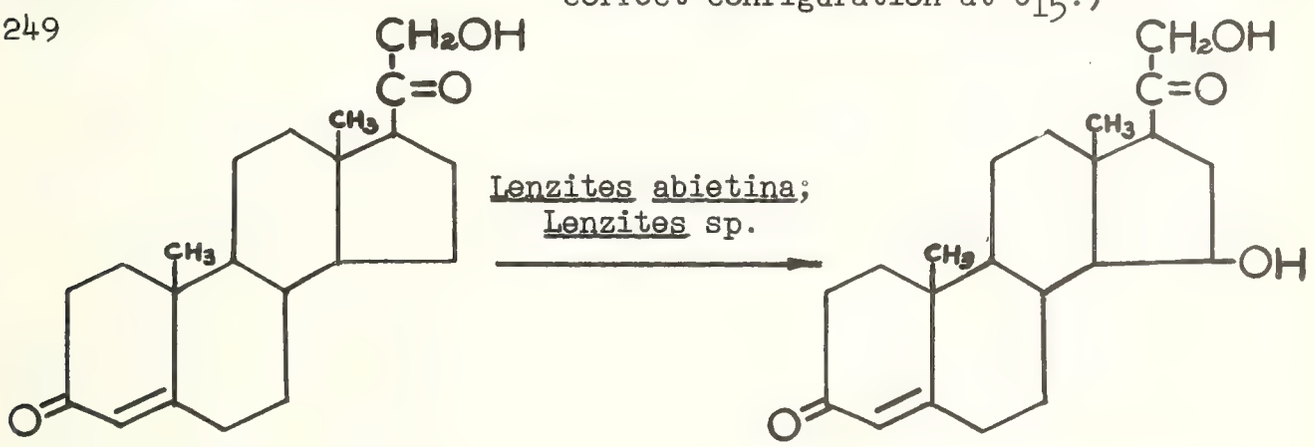


11-desoxycorticosterone (cortexone)

15α-hydroxy-11-desoxycorticosterone (20-60%)

Meystre et al., Helv. Chim. Acta 38, 381-93 (1955). (See D. H. Peterson, Record Chem. Prog. 17, p. 217 (1956) for correct configuration at C_{15}.)
C.A. 50, 12090i (1956).

Rx. 249

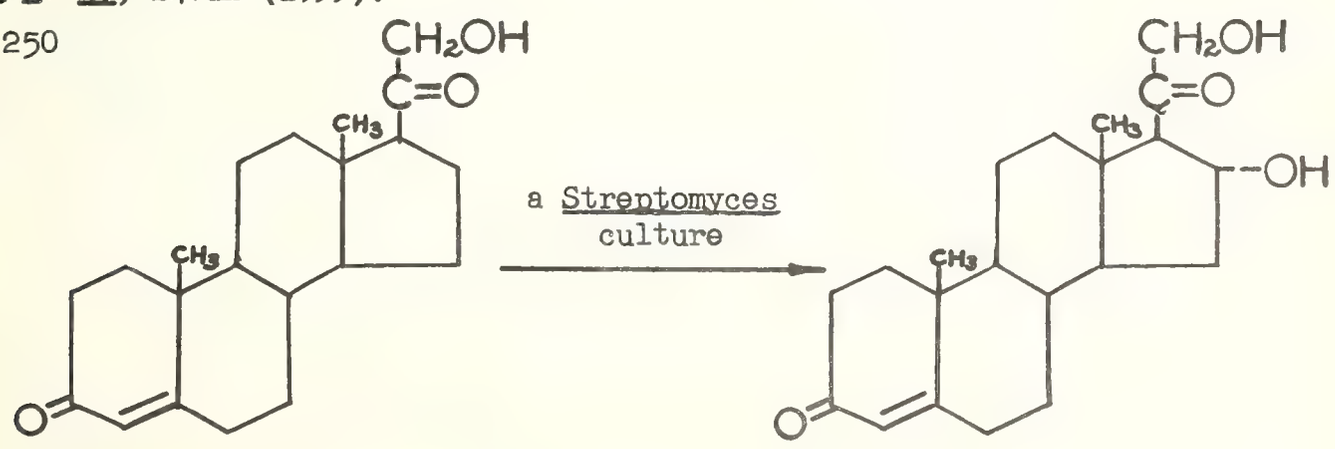


11-desoxycorticosterone

15β-hydroxy-11-desoxycorticosterone (19%)

Vischer et al., Helv. Chim. Acta 37, 321-6 (1954).
C.A. 49, 2471h (1955).

Rx. 250

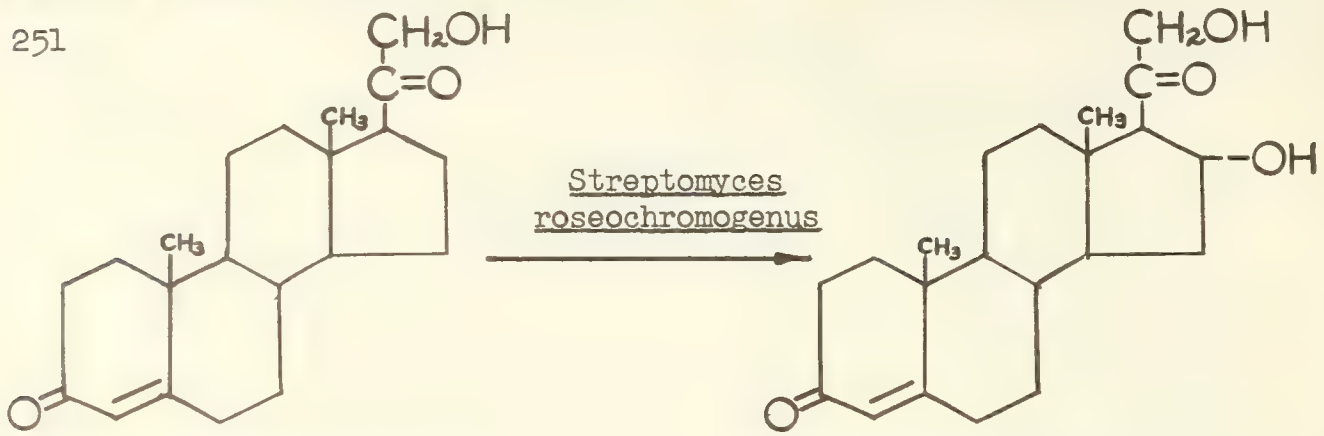


11-desoxycorticosterone

16α-hydroxy-11-desoxycorticosterone (15%)

Thoma et al., in Fried et al., Recent Progr. Hormone Research 11, 149-81, (1955).
C.A. 49, 14141b (1955).

Rx. 251

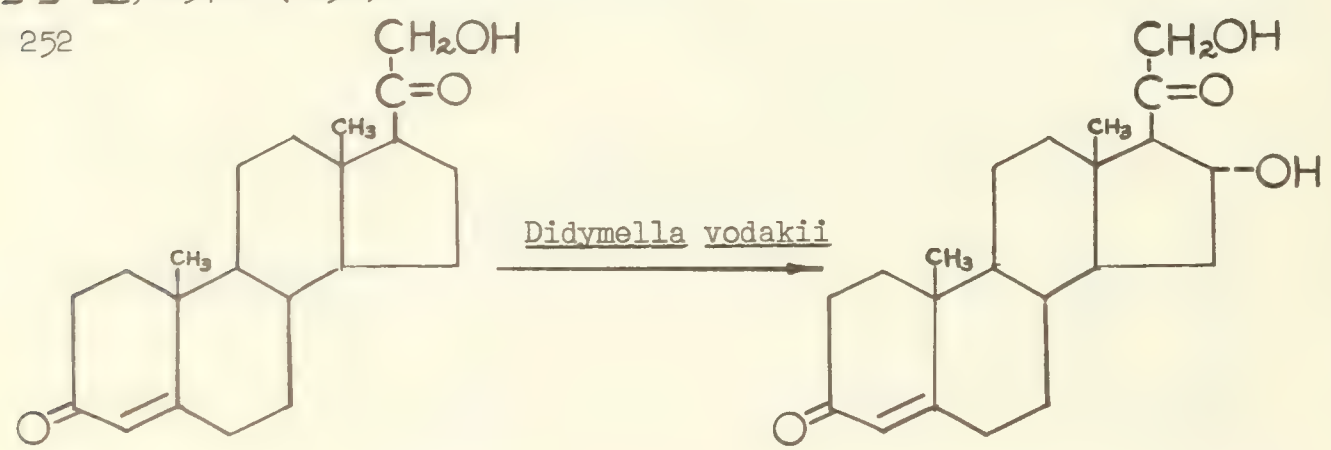


11-desoxycorticosterone

16α-hydroxy-11-desoxycorticosterone

Vischer et al., in Wettstein, Experientia 11, 465-79 (1955).
C.A. 50, 6571i (1956)

Rx. 252

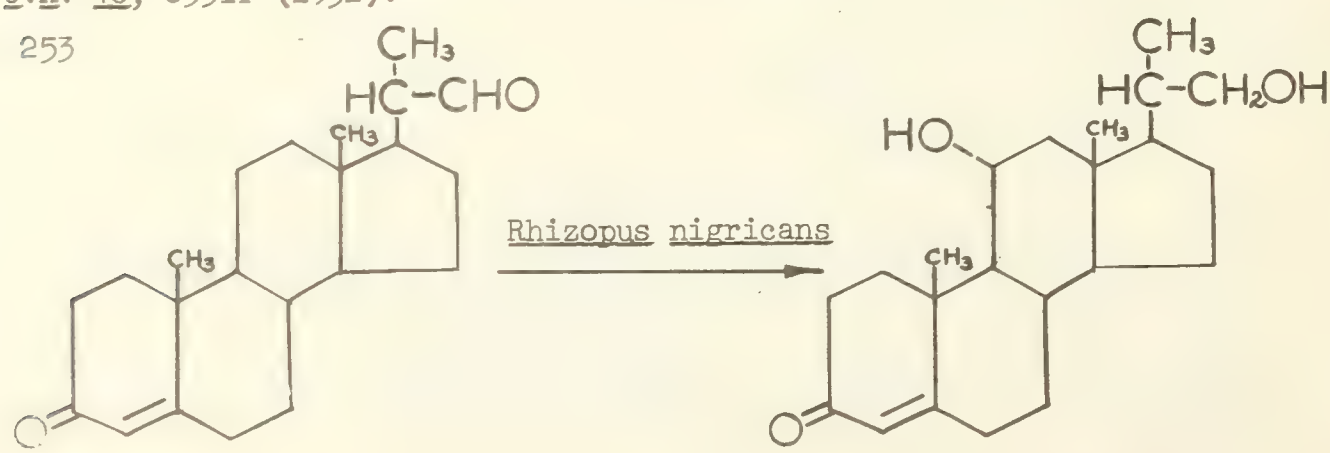


11-desoxycorticosterone

16α-hydroxy-11-desoxycorticosterone

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).
C.A. 46, 8331f (1952).

Rx. 253



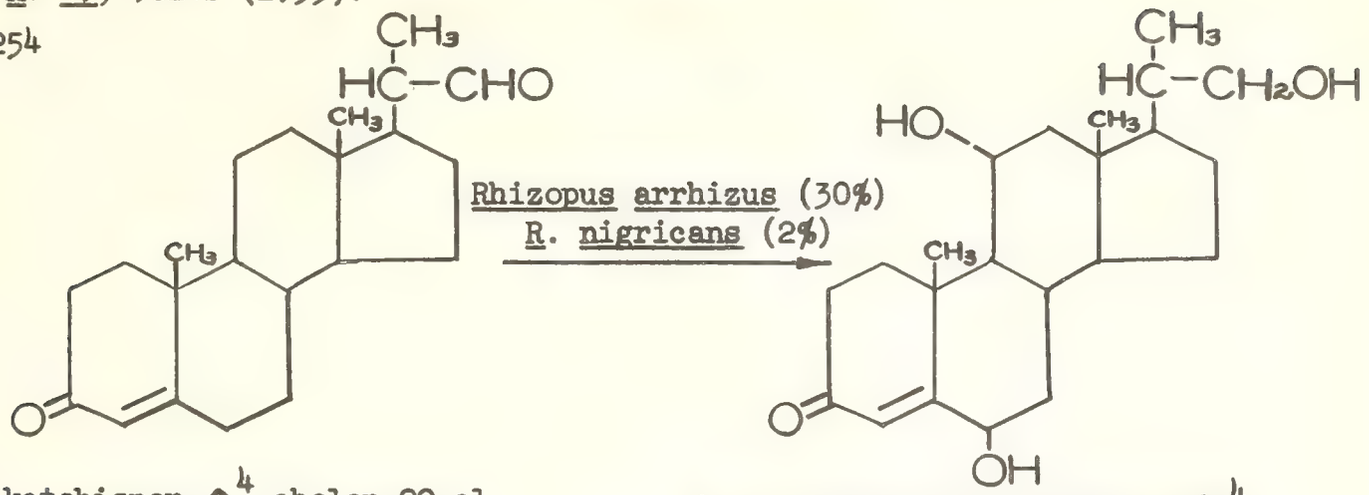
3-ketobisnor-Δ^4-cholen-22-al

3-ketobisnor-Δ^4-cholen-11α,22-diol

Meister et al., J. Am. Chem. Soc. 76, 5679-82 (1954).

C.A. 49, 9024b (1955).

Rx. 254



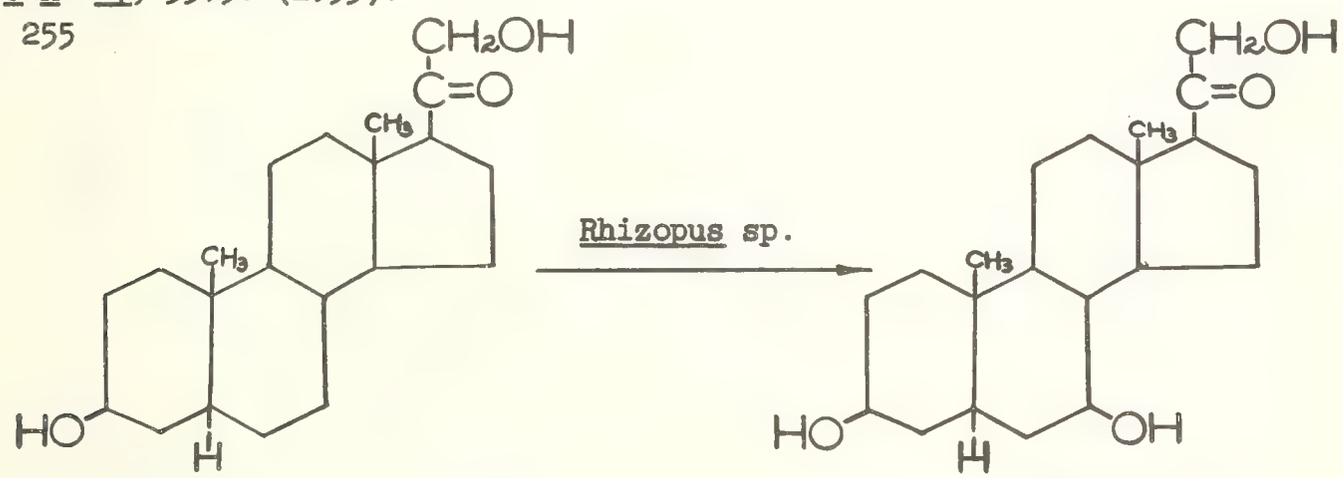
3-ketobisnor-Δ^4-cholen-22-al

6β,11α,22-trihydroxybisnor-Δ^4-cholen-3-one

Kahnt et al., Experientia 8, 422-4 (1952).

C.A. 47, 3395c (1953).

Rx. 255



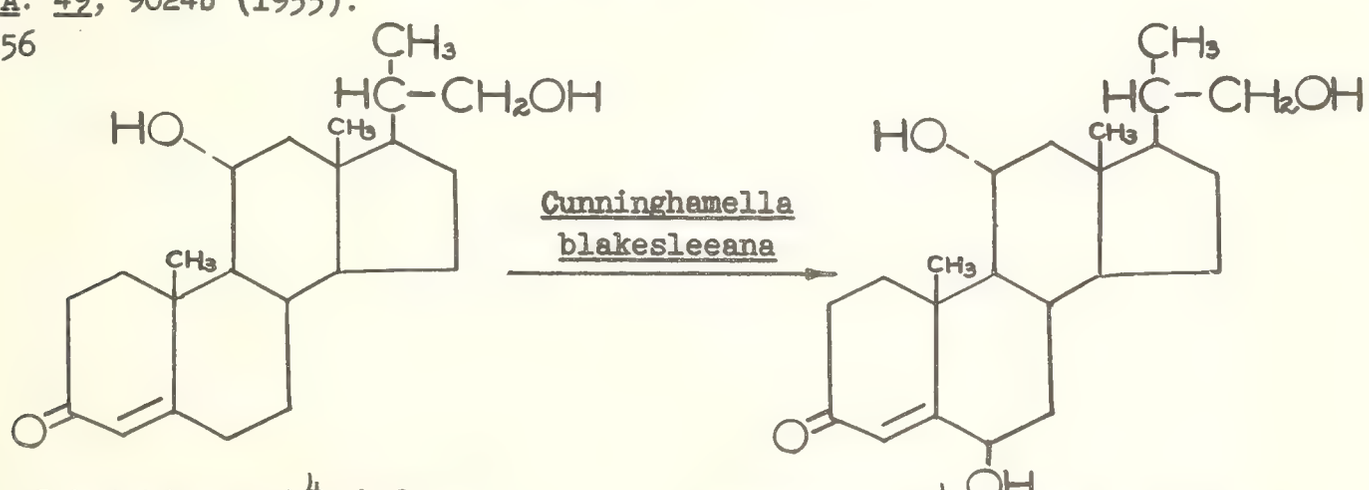
allopregnane-3β,21-diol-20-one

allopregnane-3β,7β,21-triol-20-one

Meister et al., J. Am. Chem. Soc. 76, 5679-82 (1954).

C.A. 49, 9024b (1955).

Rx. 256



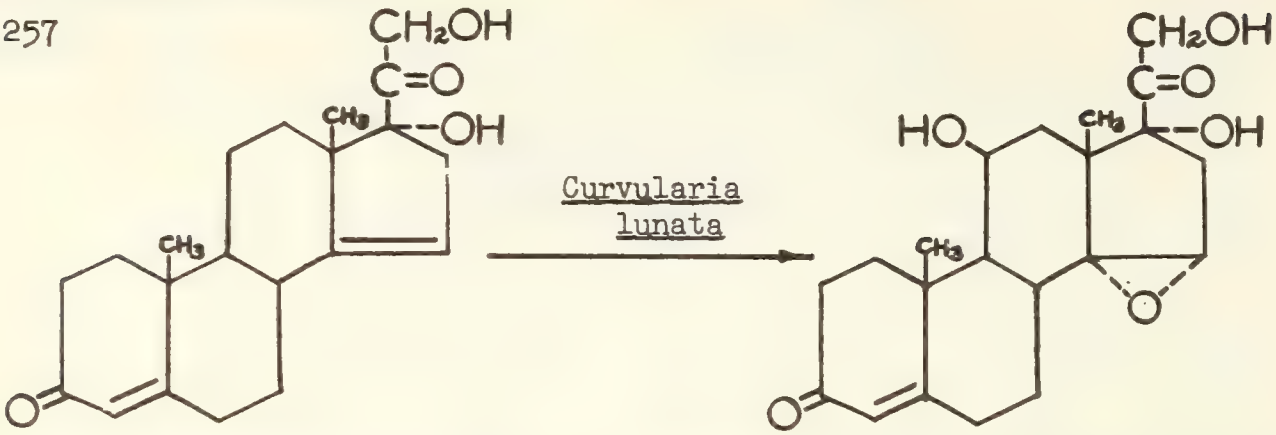
3-ketobisnor-Δ^4-cholen-11α,22-diol

3-ketobisnor-Δ^4-cholen-6β,11α,22-triol (approx. 3.5%)

Bloom et al., in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 257



$\Delta^{4,14}$-pregnadiene-17α,21-diol-3,20-dione

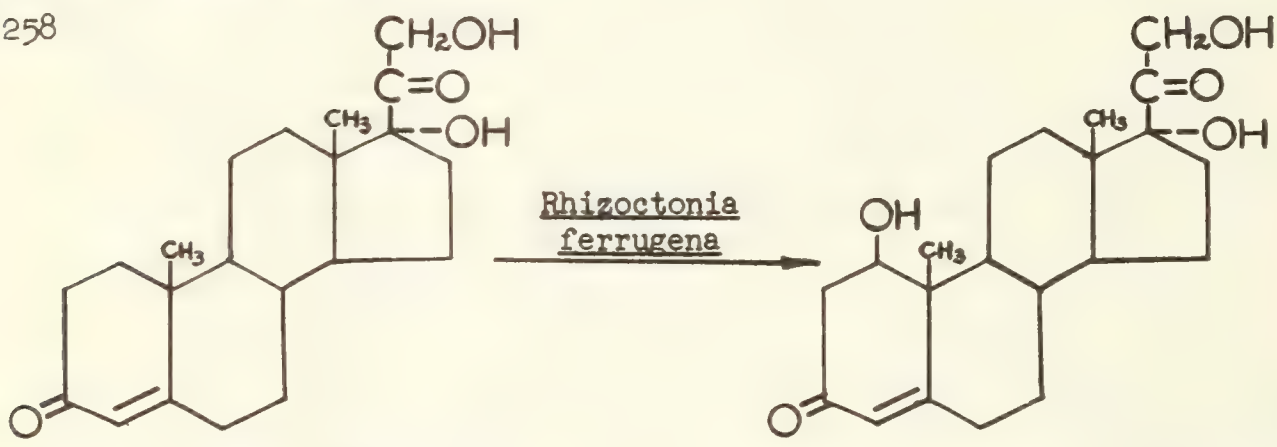
11β,17α,21-trihydroxy-14α,15α-epoxido-Δ^{4}-pregnene-3,20-dione

---

Greenspan et al., J. Am. Chem. Soc. 79, 3922-3 (1957).

C.A. 51, 18114a (1957).

Rx. 258



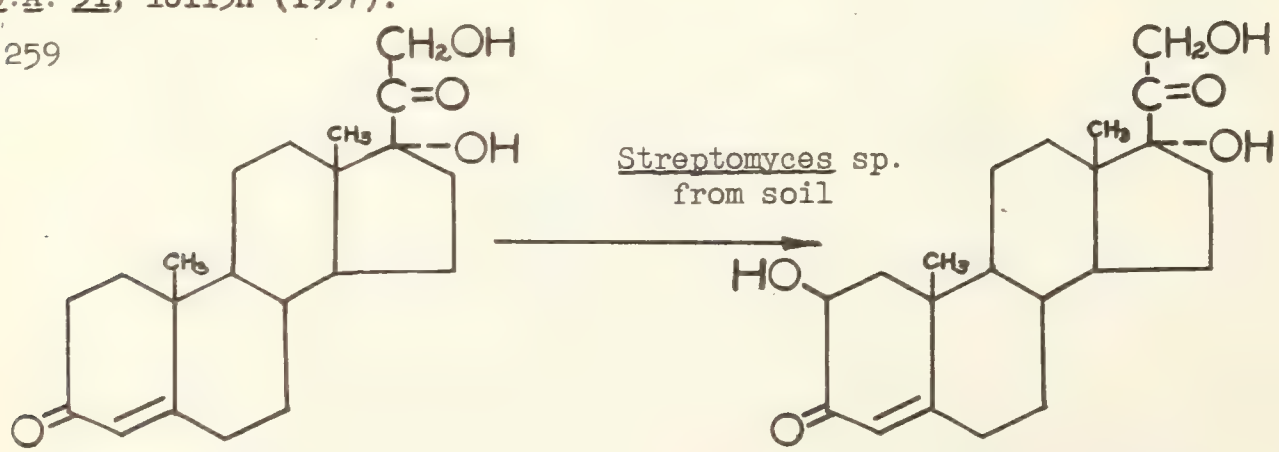
17α-hydroxy-11-desoxycorticosterone

1β,17α,21-trihydroxy-Δ^{4}-pregnene-3,20-dione (5.2%)

Herzog et al., J. Am. Chem. Soc. 79, 3921-2 (1957).

C.A. 51, 18113h (1957).

Rx. 259



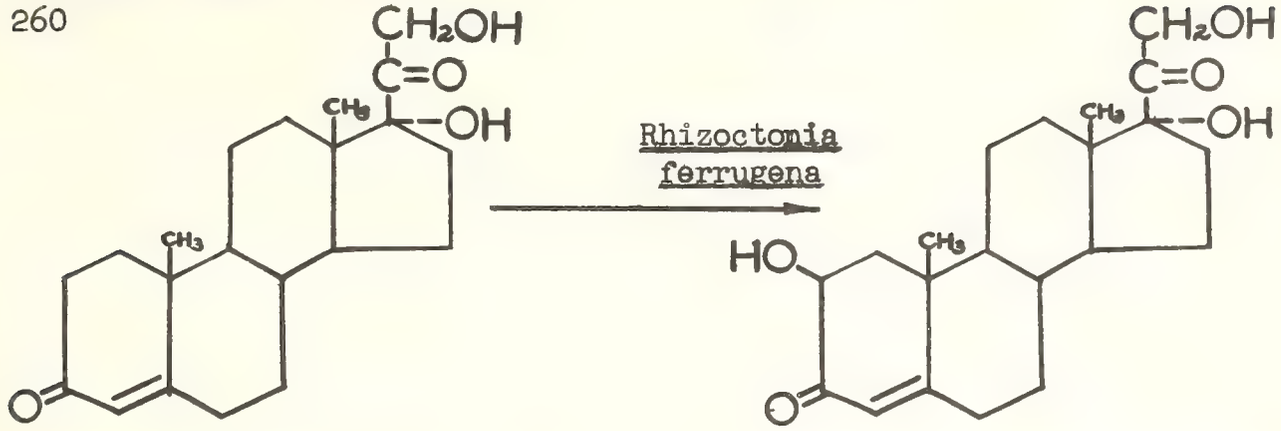
17α-hydroxy-11-desoxycorticosterone

2β,17α,21-trihydroxy-Δ^{4}-pregnene-3,20-dione (5.6%)

Greenspan et al., J. Am. Chem. Soc. 79, 3922-3 (1957).

C.A. 51, 18114a (1957).

Rx. 260



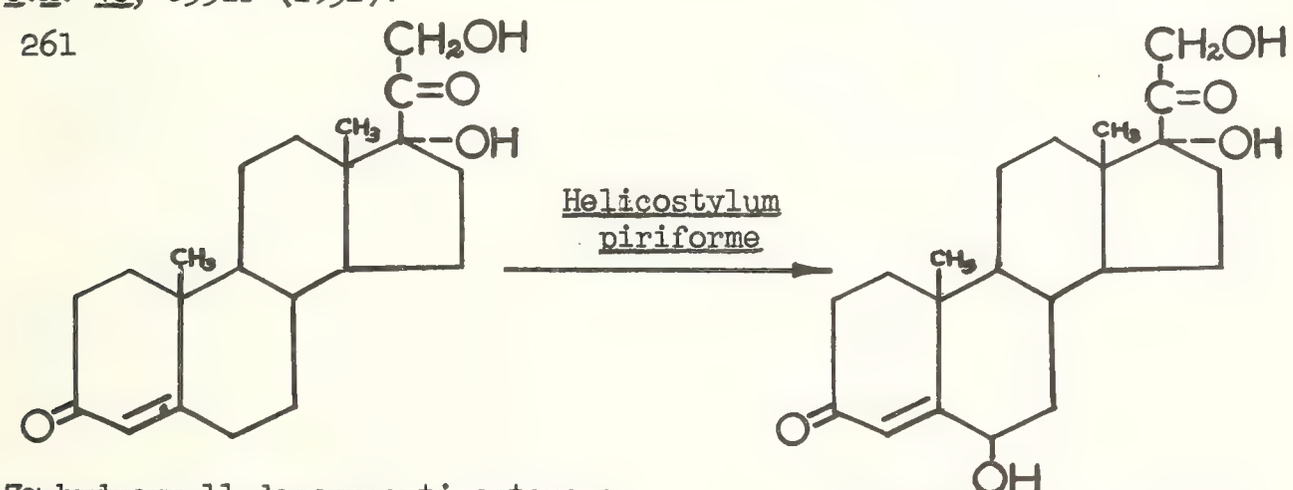
17α-hydroxy-11-desoxycorticosterone

2β,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione (3.2%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 261



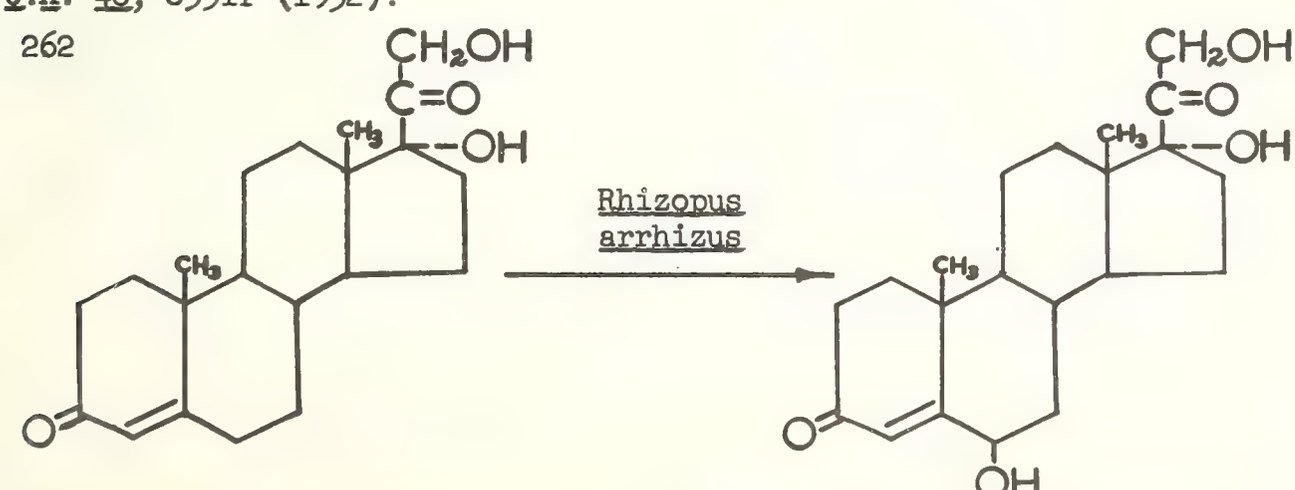
17α-hydroxy-11-desoxycorticosterone

6,17α-dihydroxy-11-desoxycorticosterone

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 262



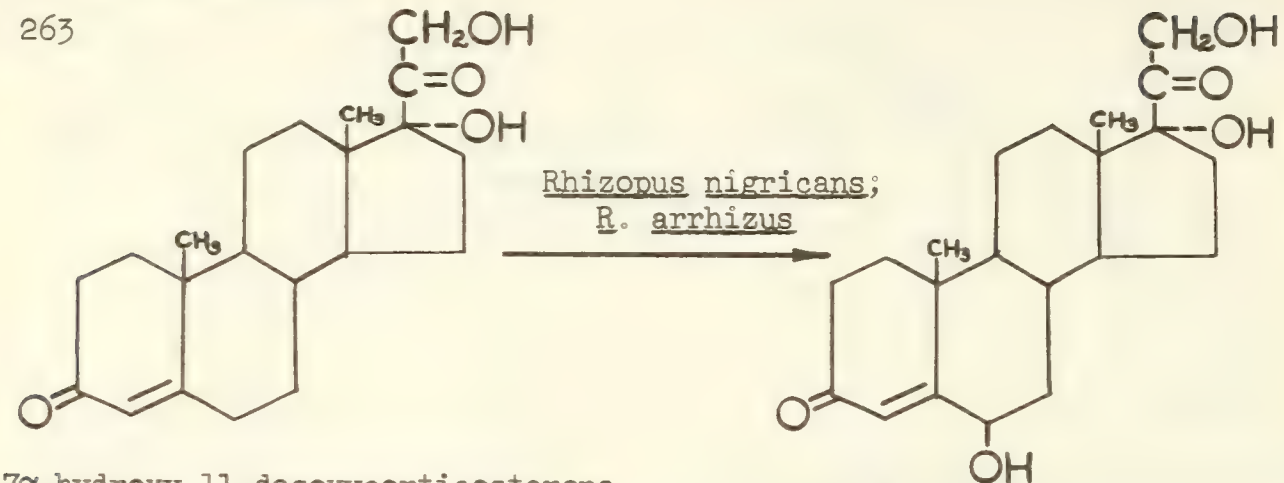
17α-hydroxy-11-desoxycorticosterone

6β,17α-dihydroxy-11-desoxycorticosterone (approx. 20%)

Peterson et al., J. Am. Chem. Soc. 75, 412-15 (1953).

C.A. 48, 2752f (1954).

Rx. 263



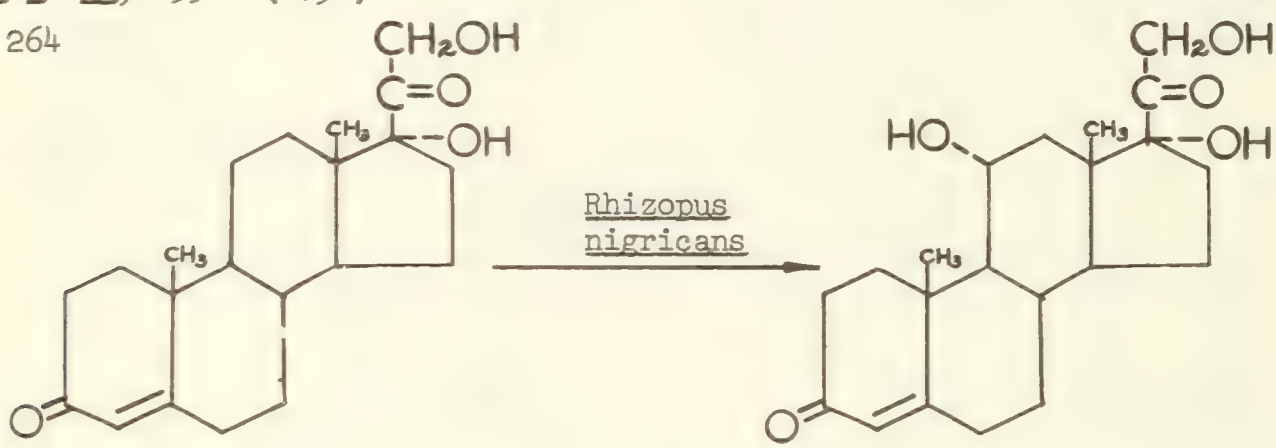
17α-hydroxy-11-desoxycorticosterone

6β,17α-dihydroxy-11-desoxy-corticosterone

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 264



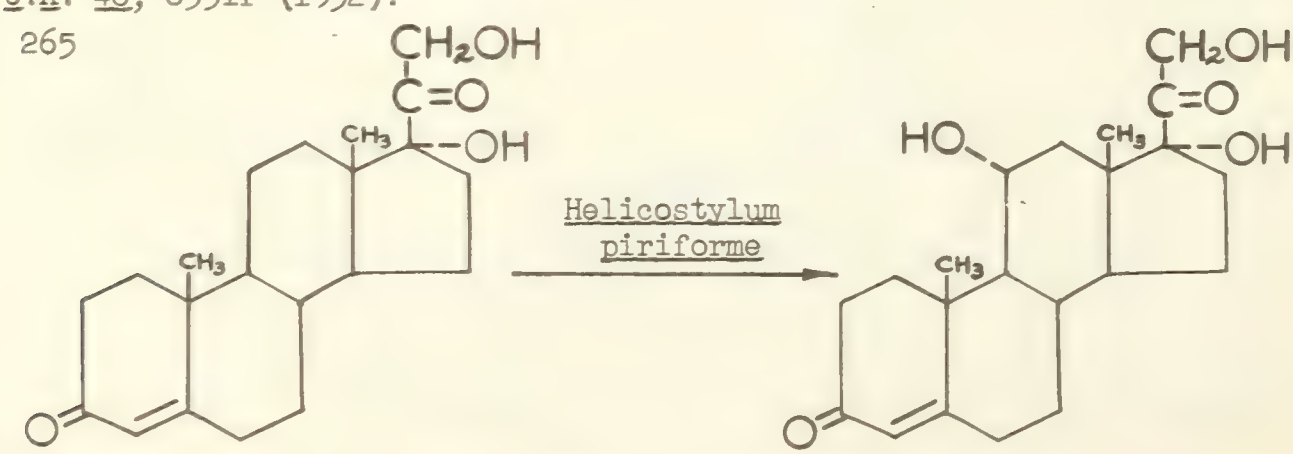
17α-hydroxy-11-desoxycorticosterone

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione (approx. 6%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 265



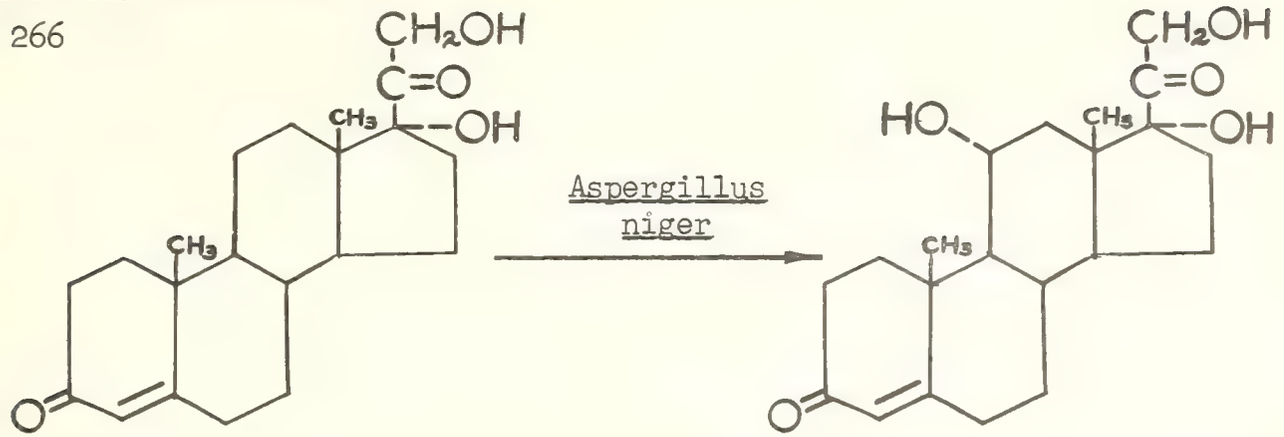
17α-hydroxy-11-desoxycorticosterone

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione

Fried et al., J. Am. Chem. Soc. 74, 3962-3 (1952).

C.A. 48, 5874a (1954).

Rx. 266



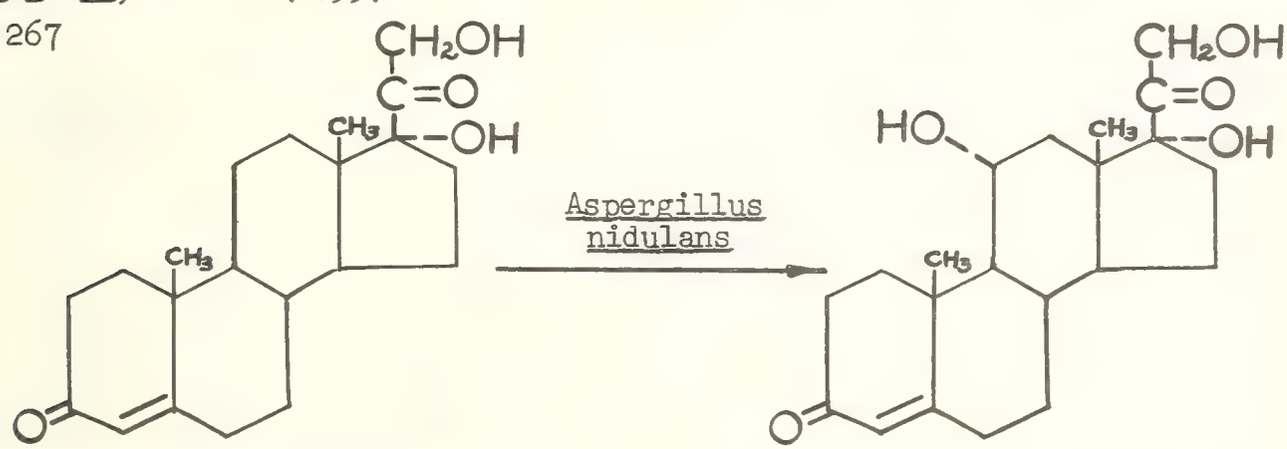
17α-hydroxy-11-desoxycorticosterone

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione (25%)

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 267



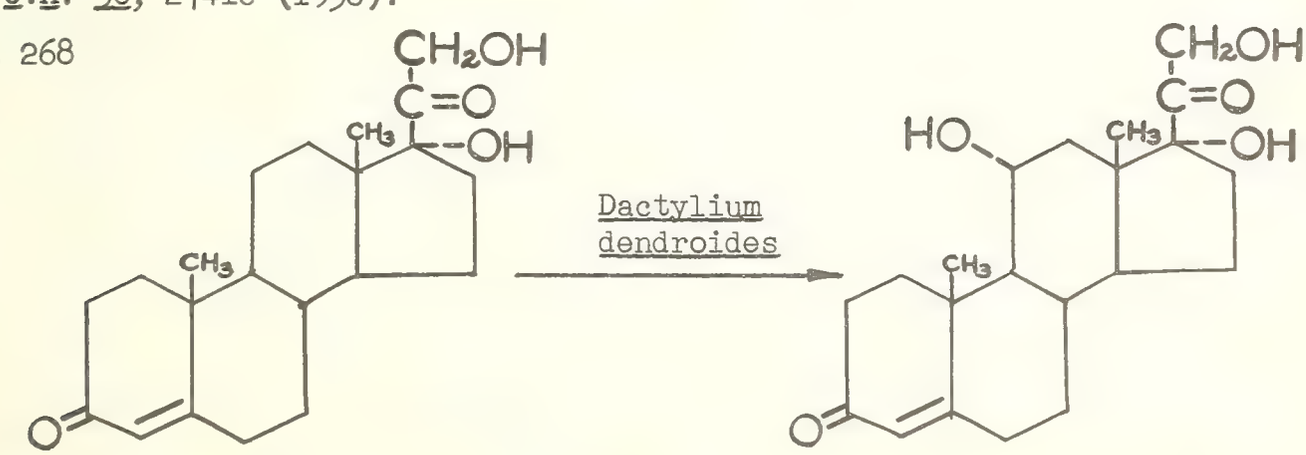
17α-hydroxy-11-desoxycorticosterone

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione (70%)

Dulaney et al., Appl. Microbiol. 3, 372-4 (1955).

C.A. 50, 2741c (1956).

Rx. 268



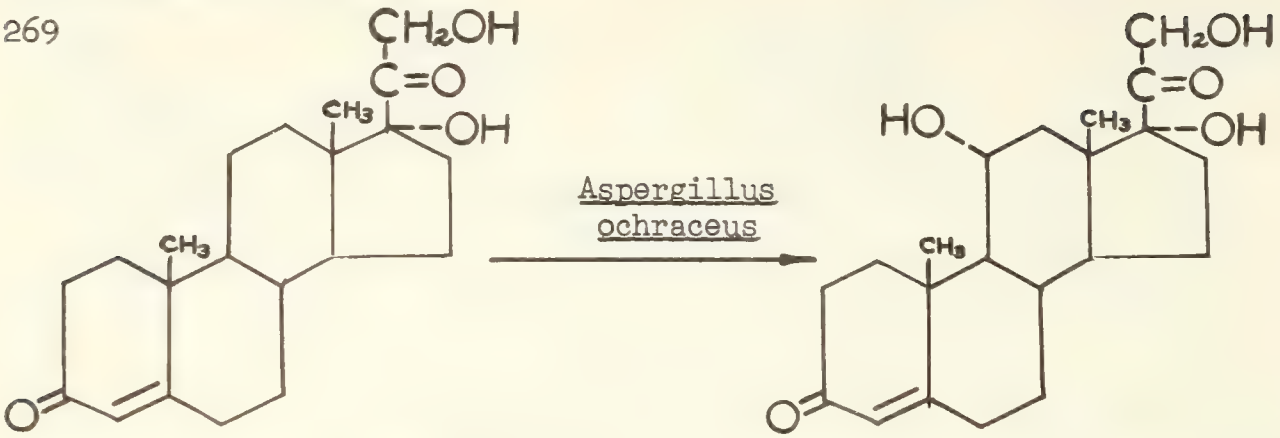
17α-hydroxy-11-desoxycorticosterone

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione (16%)

Dulaney et al., Mycologia 47, 464-74 (1955).

C.A. reference not available

Rx. 269



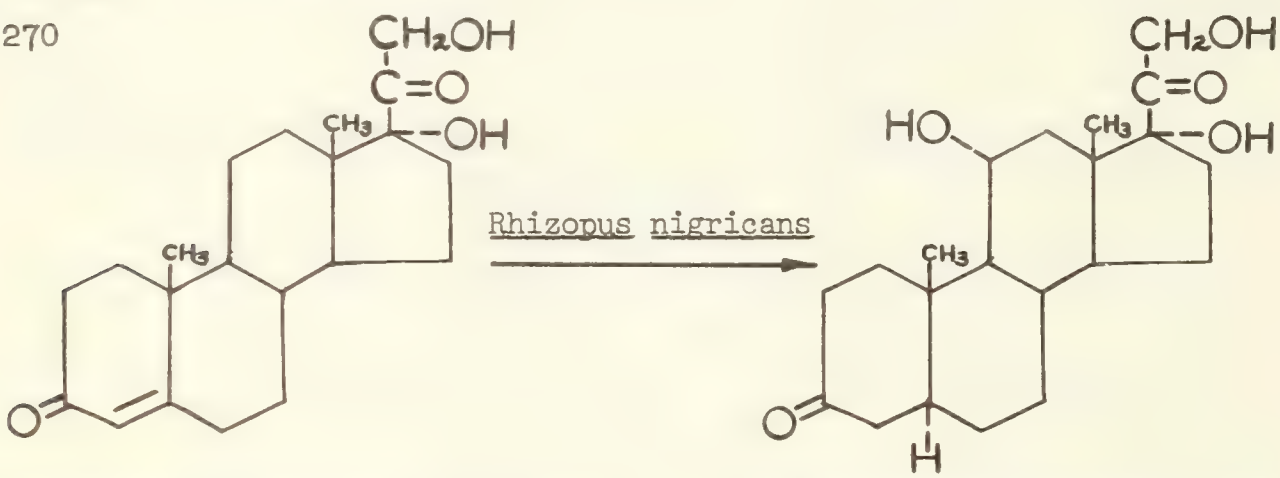
17α-hydroxy-11-desoxycorticosterone

11α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione (50%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 270



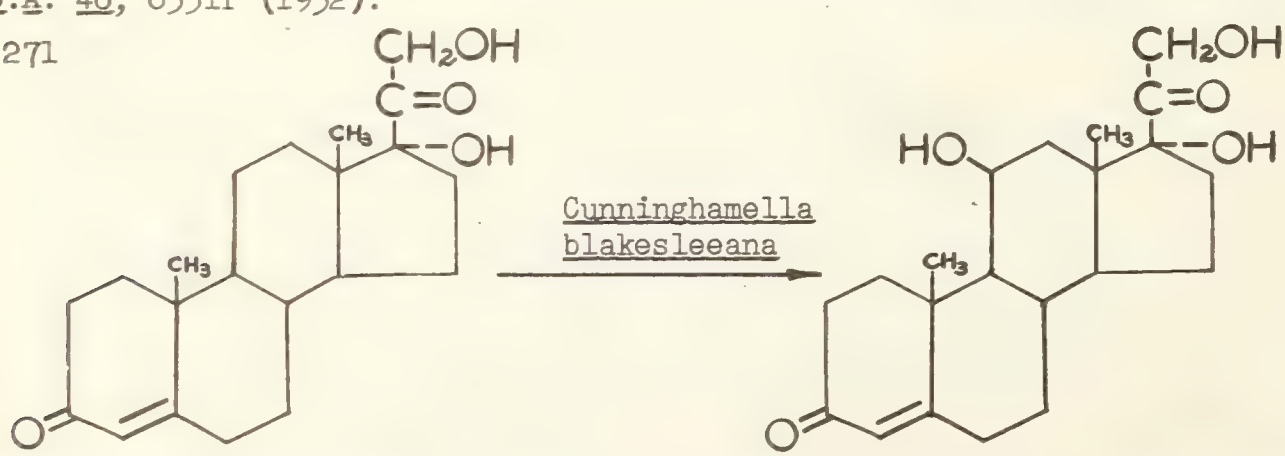
17α-hydroxy-11-desoxycorticosterone

11α,17α-21-trihydroxyallopregnane-3,20-dione (8.2%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 271



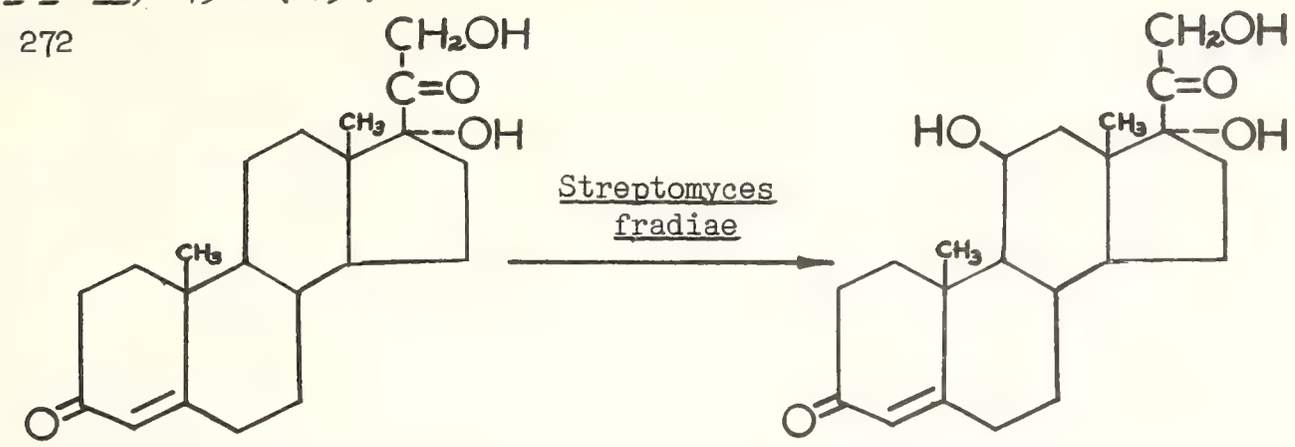
17α-hydroxy-11-desoxycorticosterone

hydrocortisone (19%)
(17α-hydroxycorticosterone)

Colingsworth et al., J. Am. Chem. Soc. 74, 2381-2 (1952).

C.A. 48, 2751d (1954).

Rx. 272



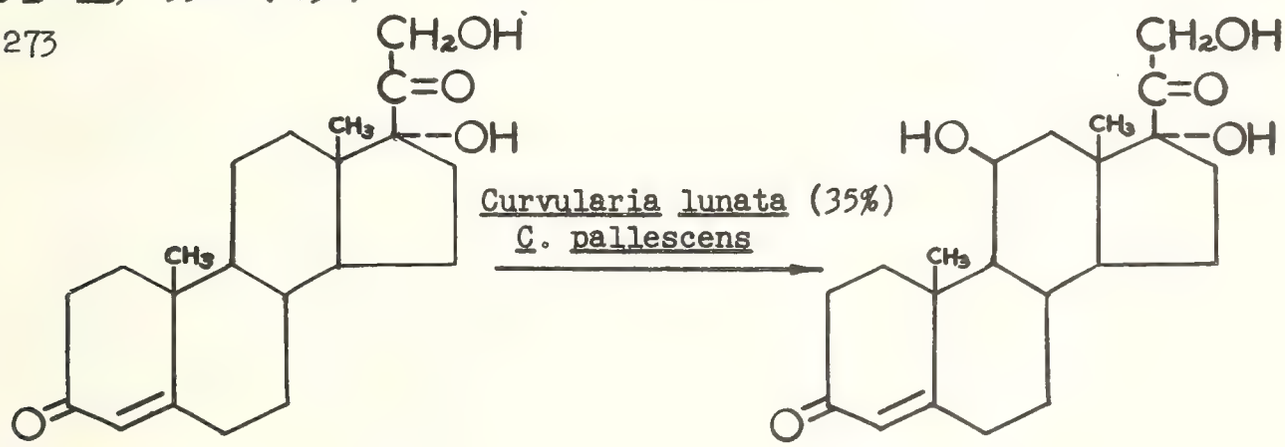
17α-hydroxy-11-desoxycorticosterone

hydrocortisone (approx. 6%)

Shull et al., U.S. 2,658,023 (Nov. 3, 1953).

C.A. 48, 2332h (1954).

Rx. 273



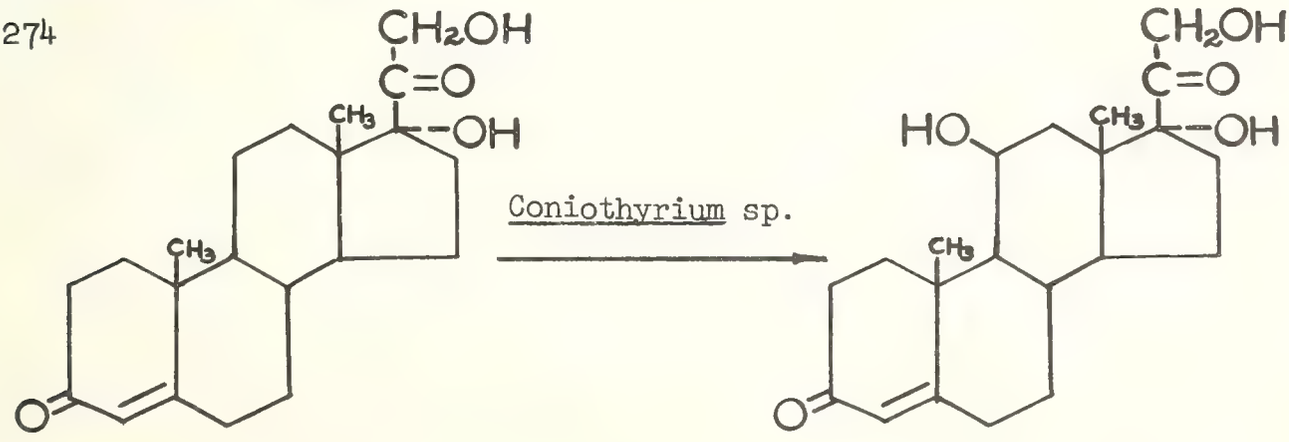
17α-hydroxy-11-desoxycorticosterone

hydrocortisone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 274

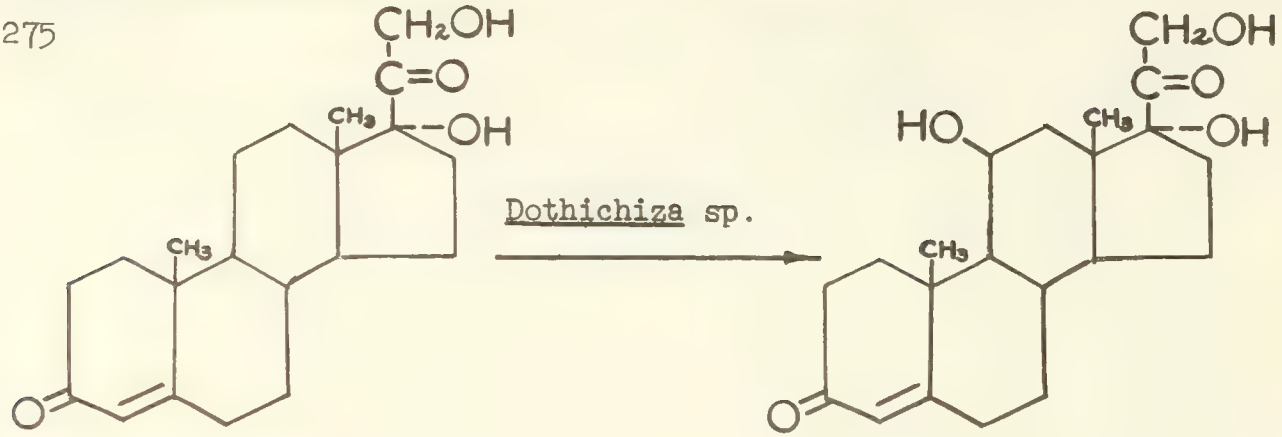


17α-hydroxy-11-desoxycorticosterone

hydrocortisone

Kita and Shull, in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).
C.A. 51, 4495c (1957).

Rx. 275

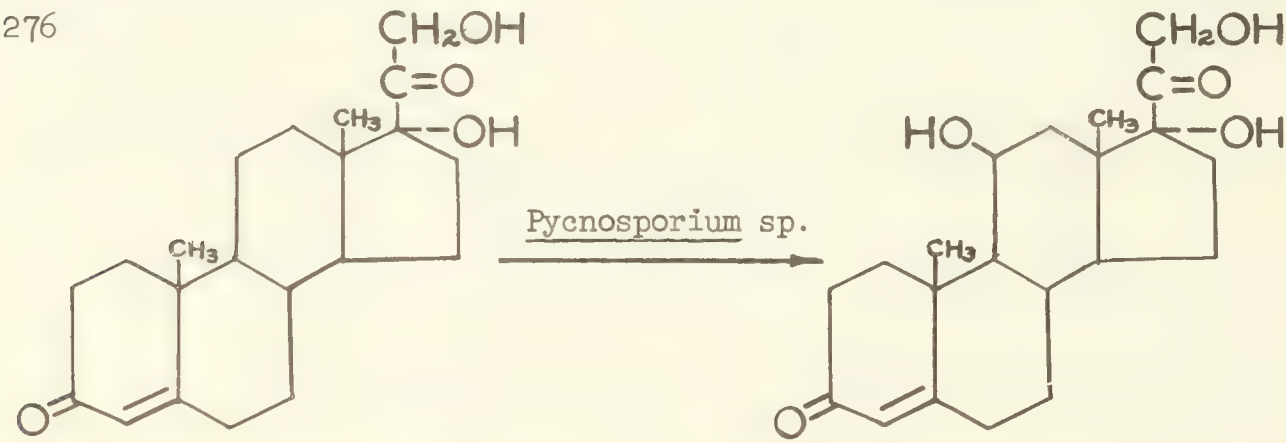


17α-hydroxy-11-desoxycorticosterone

hydrocortisone
(17α-hydroxycorticosterone)

Davisson et al., in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).
C.A. 51, 4495c (1957).

Rx. 276

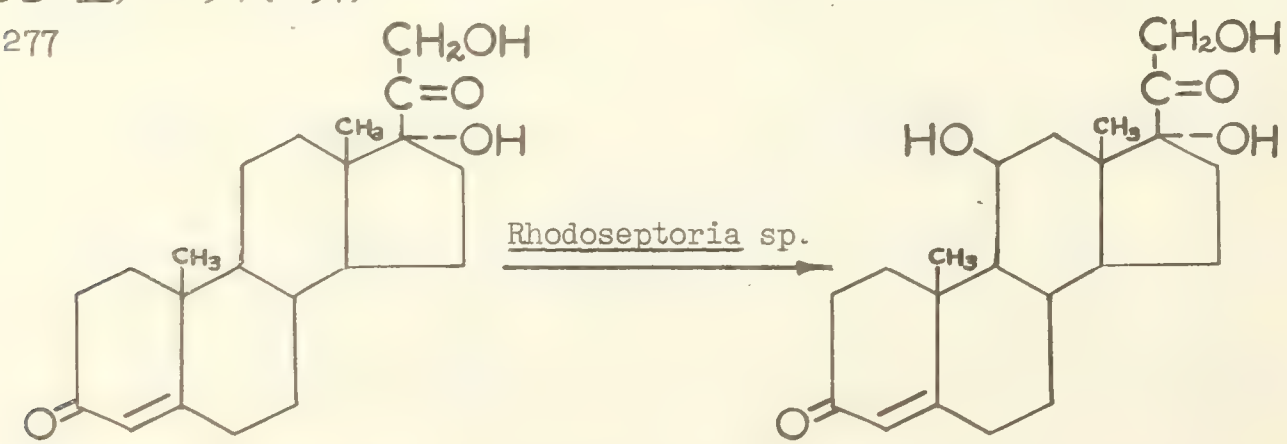


17α-hydroxy-11-desoxycorticosterone

hydrocortisone

Kita, in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).
C.A. 51, 4495c (1957).

Rx. 277



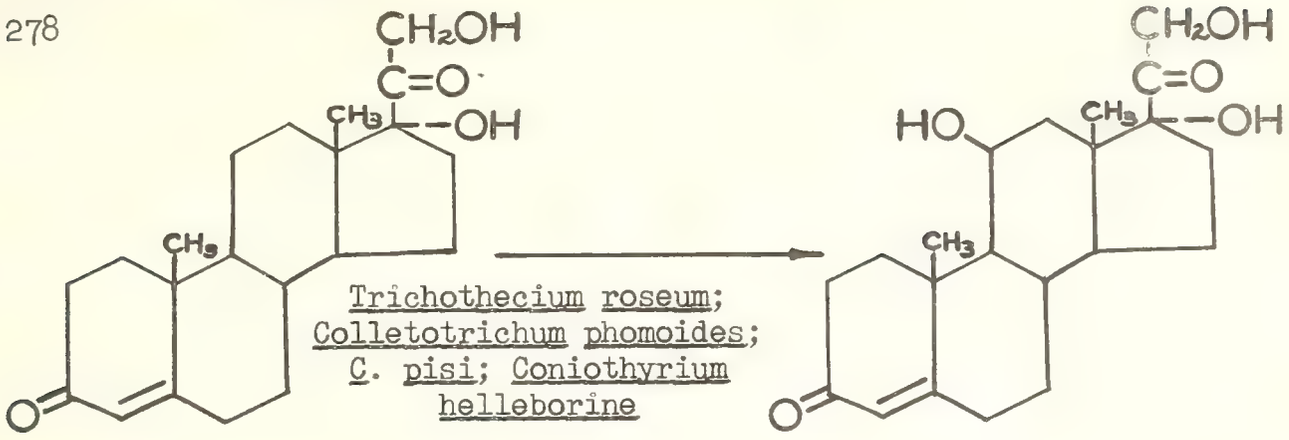
17α-hydroxy-11-desoxycorticosterone

hydrocortisone

Olin Mathieson Chemical Corp., Brit. 749,414 (May 23, 1956).

C.A. 51, 1320i (1957).

Rx. 278



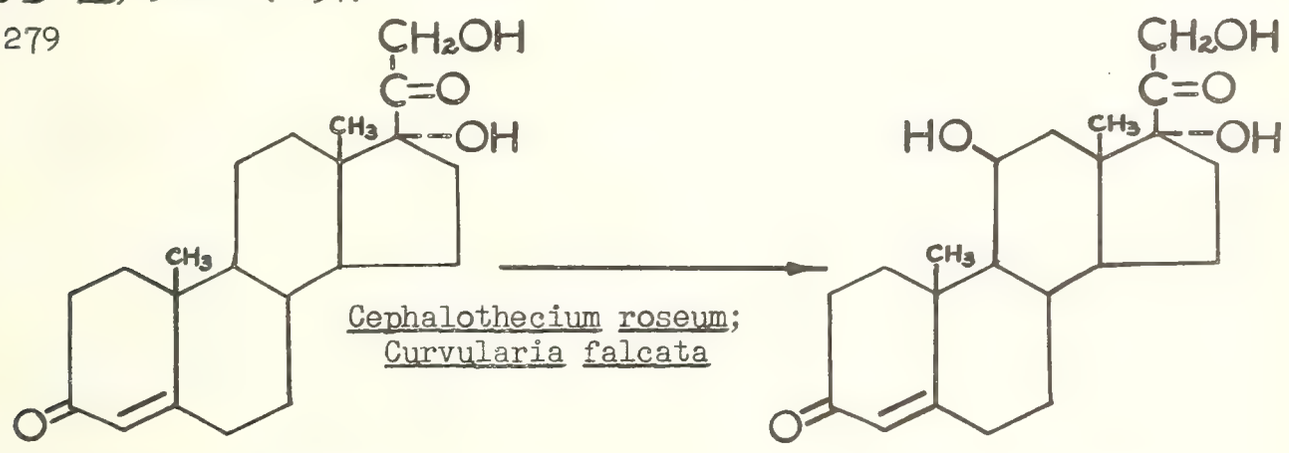
17α-hydroxy-11-desoxycorticosterone

hydrocortisone
(17α-hydroxycorticosterone)

Shull et al., U.S. 2,765,258 (Oct. 2, 1956).

C.A. 51, 3940c (1957).

Rx. 279



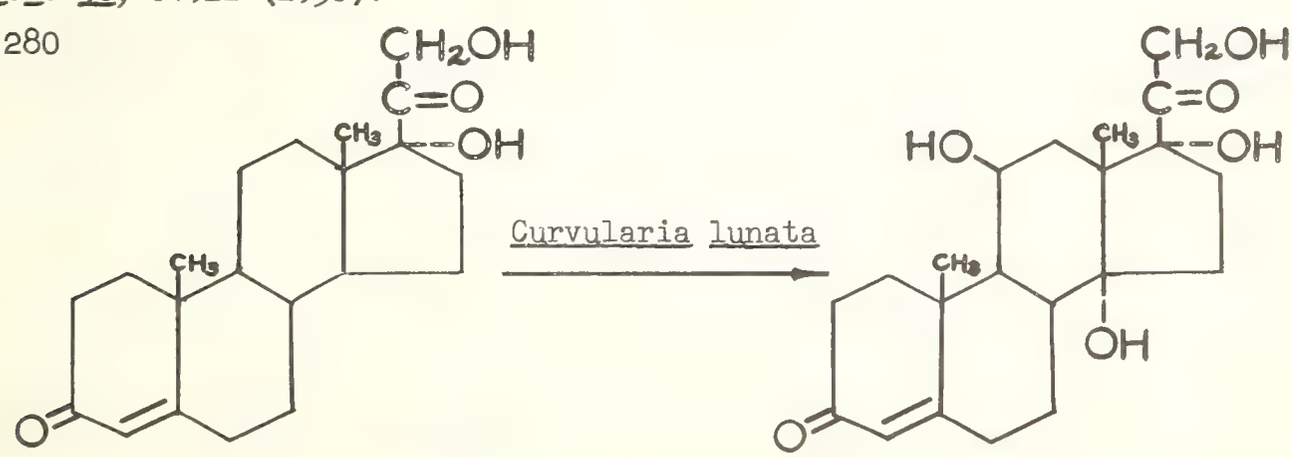
17α-hydroxy-11-desoxycorticosterone

hydrocortisone

Agnello et al., J. Am. Chem. Soc. 77, 4684-5 (1955).

C.A. 50, 6491i (1956).

Rx. 280



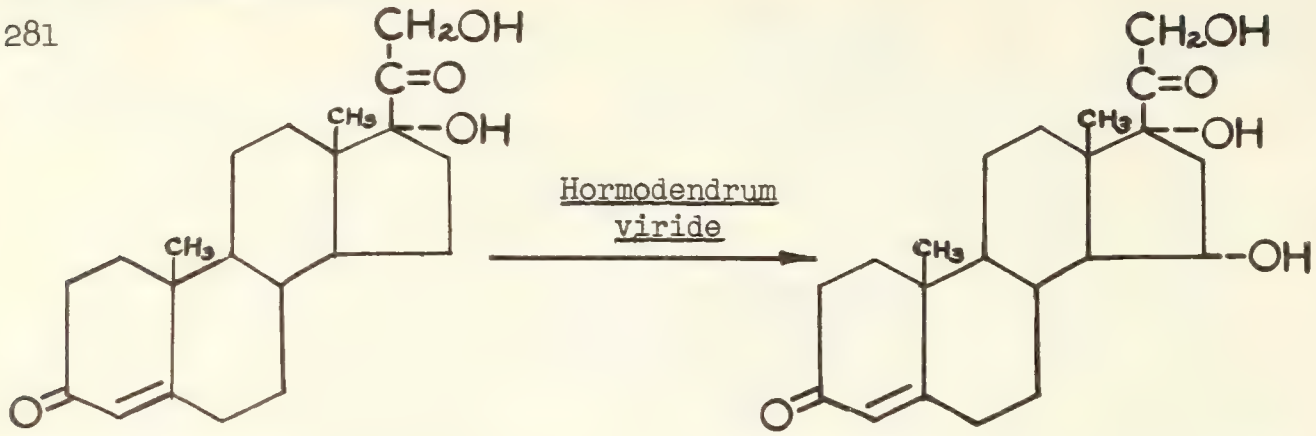
17α-hydroxy-11-desoxycorticosterone

14α-hydroxyhydrocortisone
(14α,17α-dihydroxycorticosterone)

Bernstein et al., Chemistry & Industry, 111-12 (1956).

C.A. 50, 13978h (1956).

Rx. 281



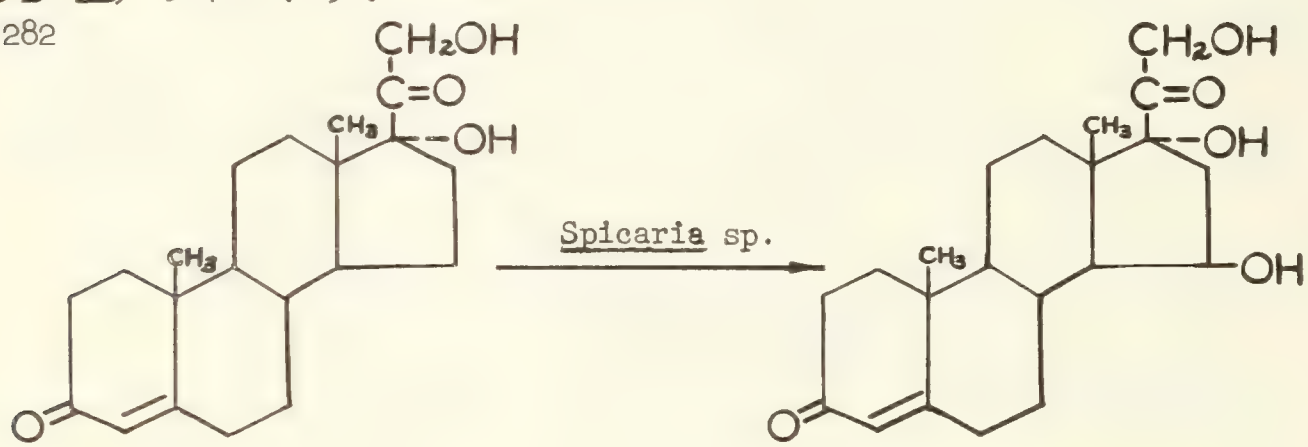
17α-hydroxy-11-desoxycorticosterone

15α,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione

Bernstein et al., Chemistry & Industry, 111-12 (1956).

C.A. 50, 13978h (1956).

Rx. 282



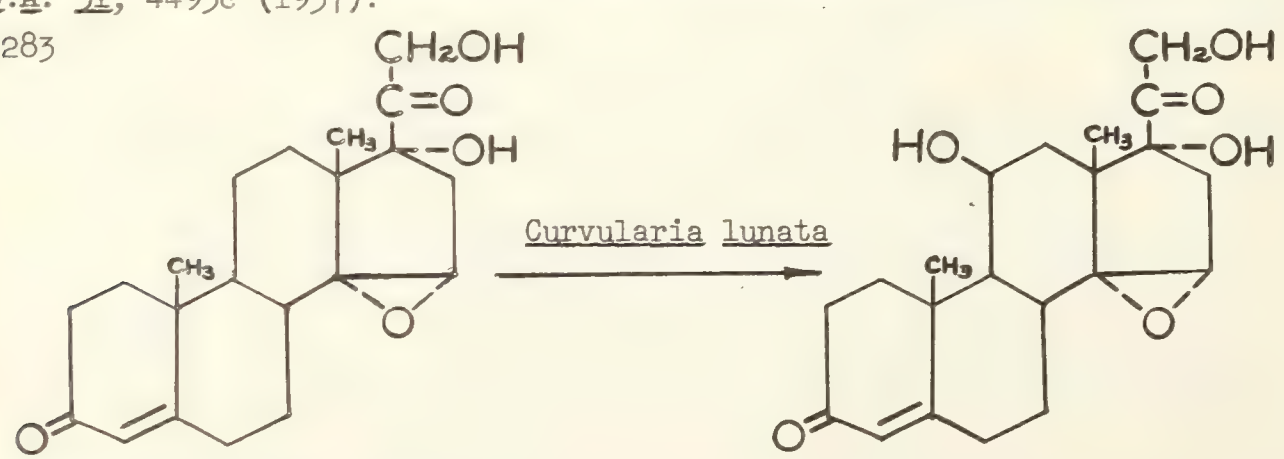
17α-hydroxy-11-desoxycorticosterone

15β,17α,21-trihydroxy-Δ^4-pregnene-3,20-dione

Bloom et al., in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 283



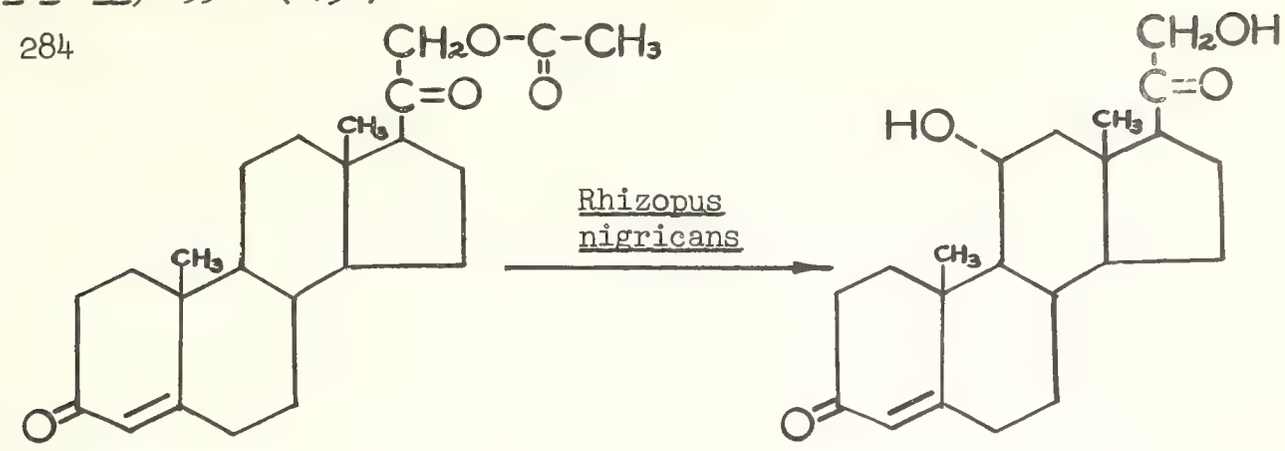
14α,15α-epoxido-17α,21-dihydroxy-^{4}-pregnene-3,20-dione

14α,15α-epoxidohydrocortisone

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 284



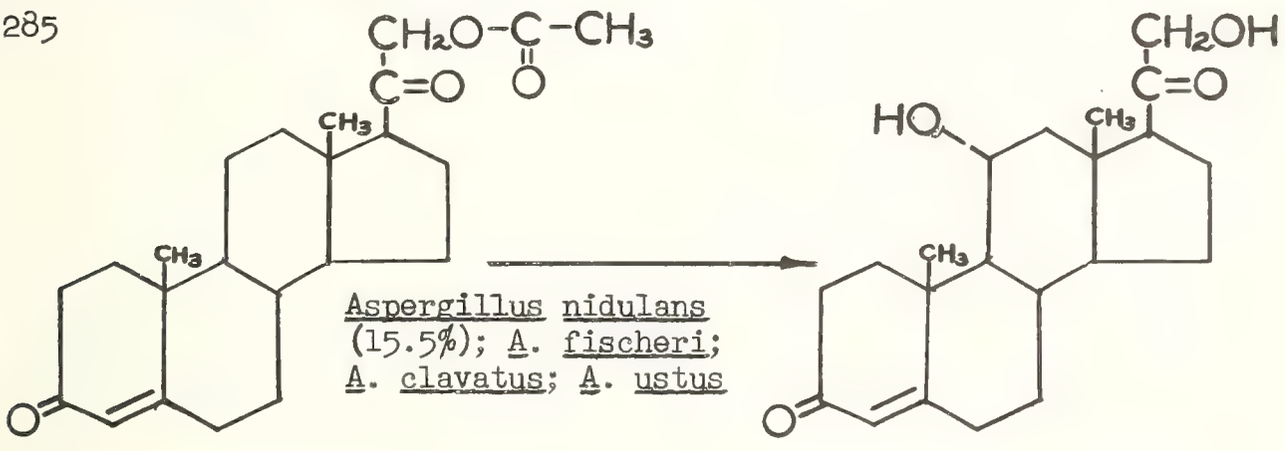
11-desoxycorticosterone acetate

11α,21-dihydroxy-Δ^4-pregnene-3,20-dione

Murray and Peterson, U.S. 2,649,402 (Aug. 18, 1953).

C.A. reference not available

Rx. 285



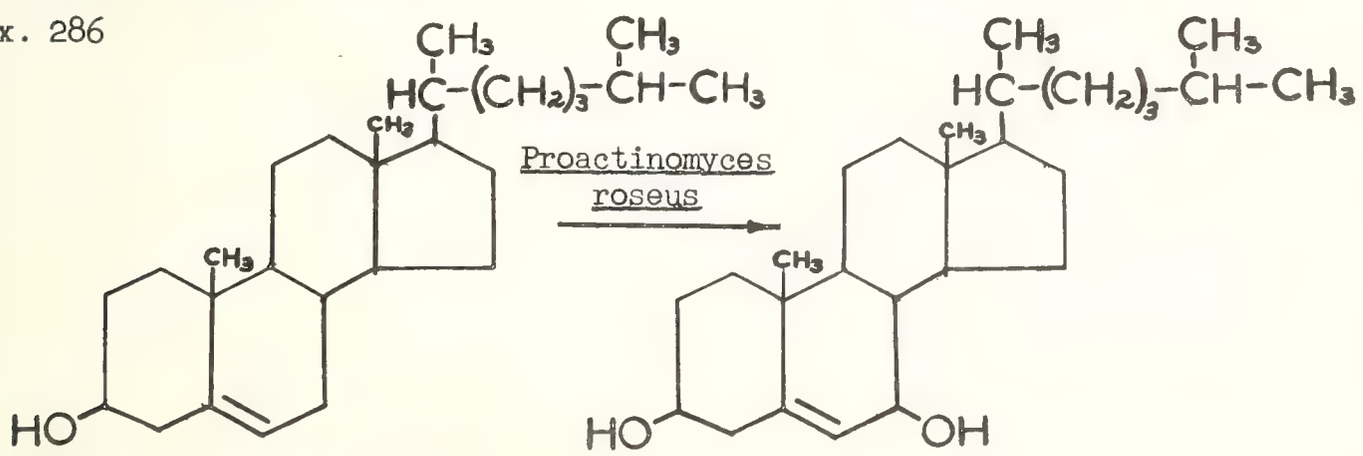
11-desoxycorticosterone acetate

11α,21-dihydroxy-Δ^4-pregnene-3,20-dione

Krámli and Horváth, Nature 162, 619 (1948).

C.A. 43, 4333f (1949).

Rx. 286



cholesterol

7-hydroxycholesterol

I. Oxidation

c. $-CHO \longrightarrow -COOH$

Supniewski, Compt. rend. soc. biol. 89, 1377-9 (1923).

C.A. 18, 3618[3] (1924).

Rx. 287

$$CH_3-CHO \xrightarrow{\text{Pseudomonas aeruginosa (Bacillus pyocyaneus)}} CH_3-COOH$$

acetaldehyde — acetic acid

Voisenet, Compt. rend. 151, 518-20 (1910).

C.A. 4, 3117[4] (1910).

Rx. 288

$$CH_2=CH-CHO \xrightarrow{\text{wine yeast}} CH_2=CH-COOH$$

acrolein — acrylic acid

Simon, Biochem. Z. 224, 253-91 (1930).

C.A. 24, 5329[9] (1930).

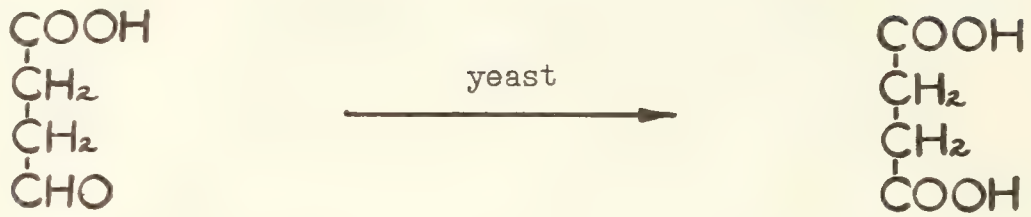
Rx. 289

$$CH_3-\overset{\overset{O}{\|}}{C}-CHO \xrightarrow{\text{Acetobacter suboxydans}} CH_3-\overset{\overset{OH}{|}}{C}H-COOH$$

methylglyoxal (pyruvic aldehyde) — lactic acid (68%)

Neuberg and Ringer, Biochem. Z. 91, 131-6 (1918).
C.A. 13, 2046[4] (1919).

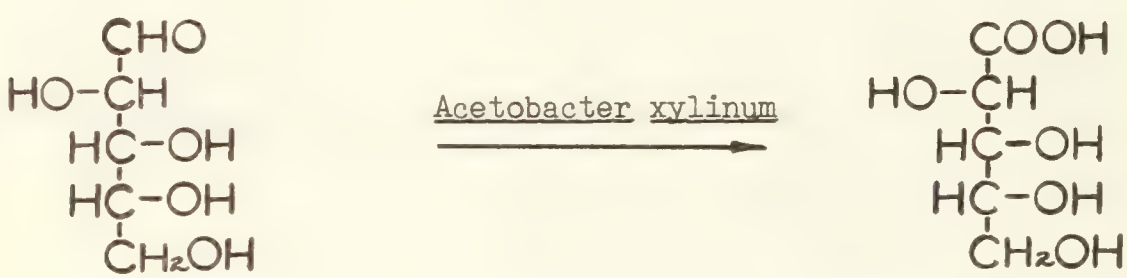
Rx. 290



β-formylpropionic acid — succinic acid (8-24%)

Bertrand, Compt. rend. 127, 728-30 (1898).
Brit. C.A. 76 [ii], 170 (1899).

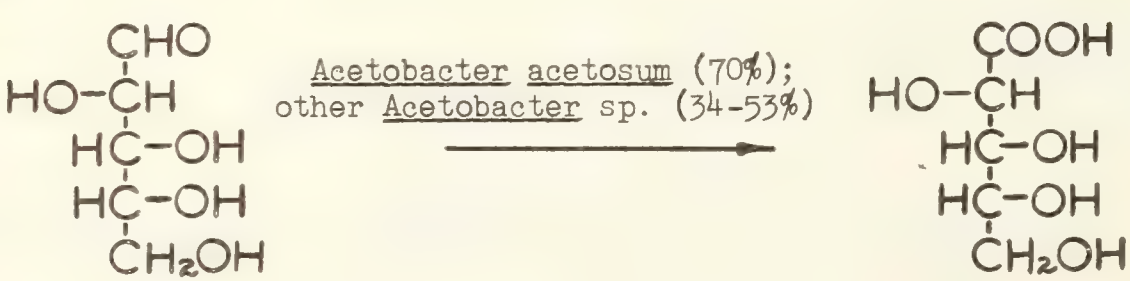
Rx. 291



arabinose — arabonic acid (13.3%)

Hermann and Neuschul, Biochem. Z. 233, 129-216 (1931).
C.A. 25, 3684 (1931).

Rx. 292

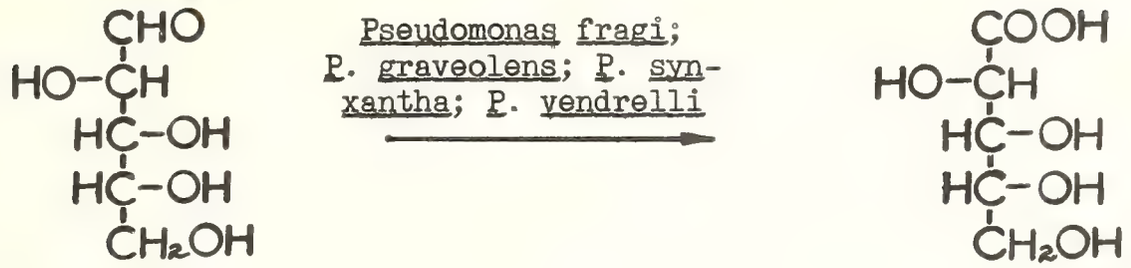


D-arabinose — D-arabonic acid

Lockwood and Nelson, J. Bacteriol. 52, 581-6 (1946).

C.A. 41, 789g (1947).

Rx. 293

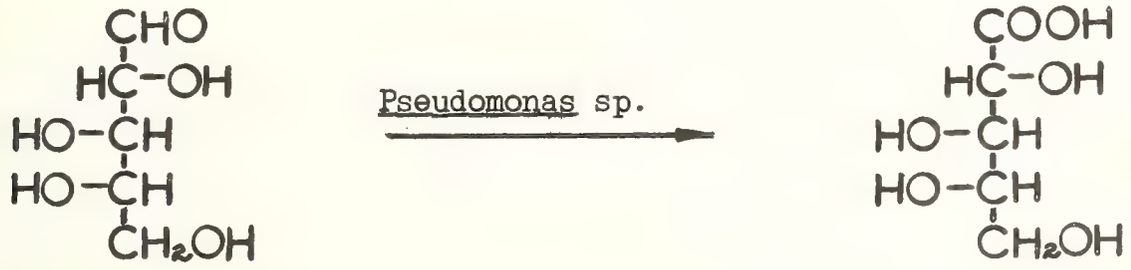


D-arabinose — D-arabonic acid (15-25%)

Lockwood and Nelson, J. Bacteriol. 52, 581-6 (1946).

C.A. 41, 789g (1947).

Rx. 294

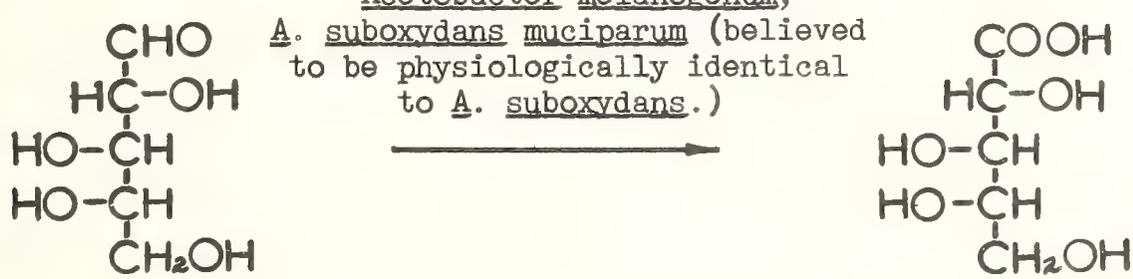


L-arabinose — L-arabonic acid (17.5-48%)

Bernhauer and Riedl-Tůmová, Biochem. Z. 321, 26-30 (1950).

C.A. 45, 709d (1951).

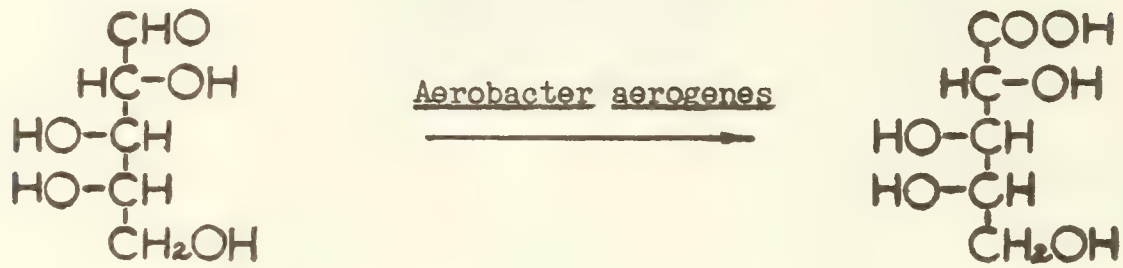
Rx. 295



L-arabinose — L-arabonic acid

Masuo and Nozaki, Ann. Rept. Shionogi Research Lab. No. 6, 110-14 (1956).
C.A. 51, 5192f (1957).

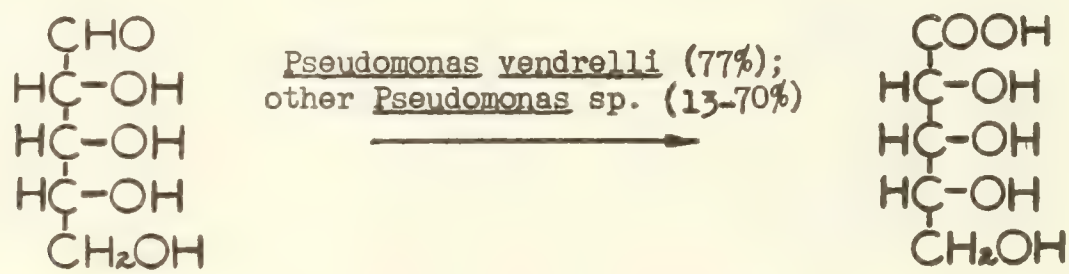
Rx. 296



L-arabinose — L-arabonic acid

Lockwood and Nelson, J. Bacteriol. 52, 581-6 (1946).
C.A. 41, 789g (1947).

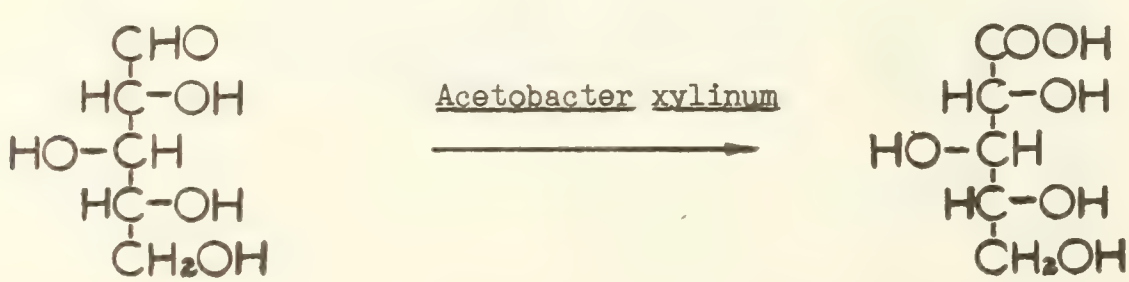
Rx. 297



D-ribose — D-ribonic acid

Bertrand, Compt. rend. 127, 124-7 (1898).
Brit. C.A. 76 /ii/, 44 (1899).

Rx. 298

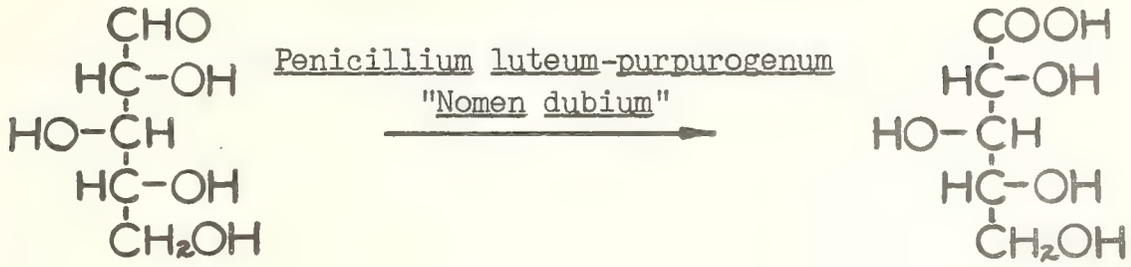


xylose — xylonic acid (10%)

Angeletti and Cerutti, Ann. chim. applicata 21, 491-6 (1931).

C.A. 26, 1637[4] (1932).

Rx. 299

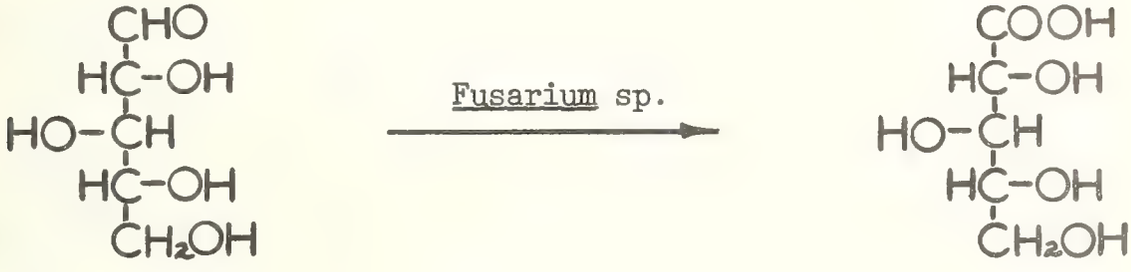


xylose — xylonic acid

Hayasida, Biochem. Z. 298, 169-78 (1938).

C.A. 33, 199[4] (1939).

Rx. 300

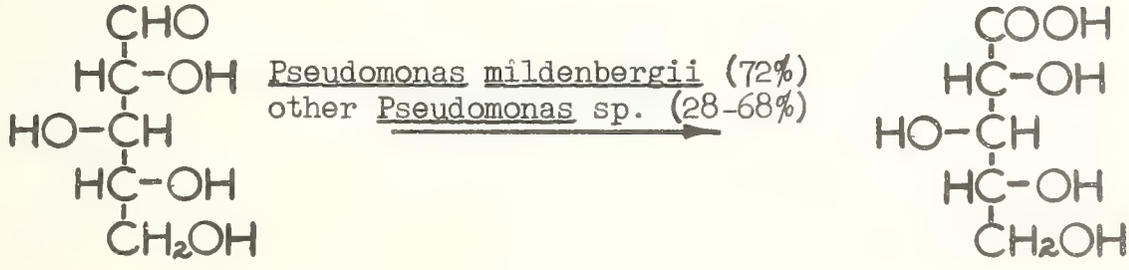


D-xylose — D-xylonic acid (39%)

Lockwood and Nelson, J. Bacteriol. 52, 581-6 (1946).

C.A. 41, 789g (1947).

Rx. 301

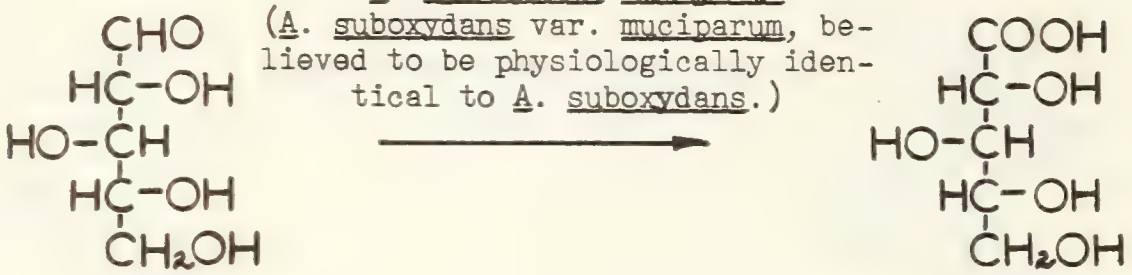


D-xylose — D-xylonic acid

Bernhauer and Riedl-Tůmová, Biochem. Z. 321, 26-30 (1950).

C.A. 45, 709d (1951).

Rx. 302


Acetobacter melanogenum;
A. suboxydans muciparum
(A. suboxydans var. muciparum, believed to be physiologically identical to A. suboxydans.)

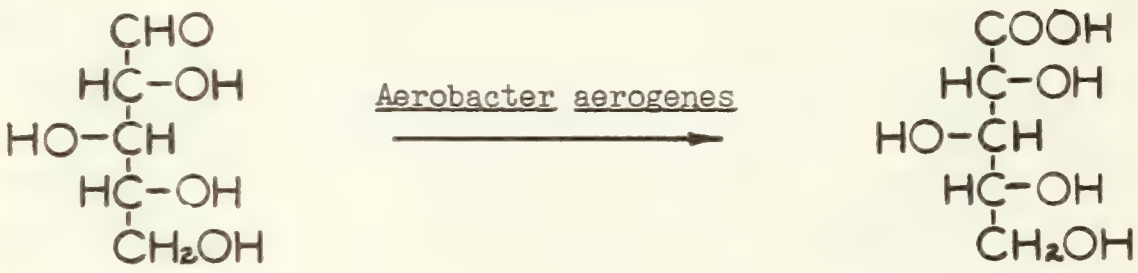
D-xylose

D-xylonic acid

Masuo and Nozaki, Ann. Rept. Shionogi Research Lab. No. 6, 110-14 (1956).

C.A. 51, 5192f (1957).

Rx. 303



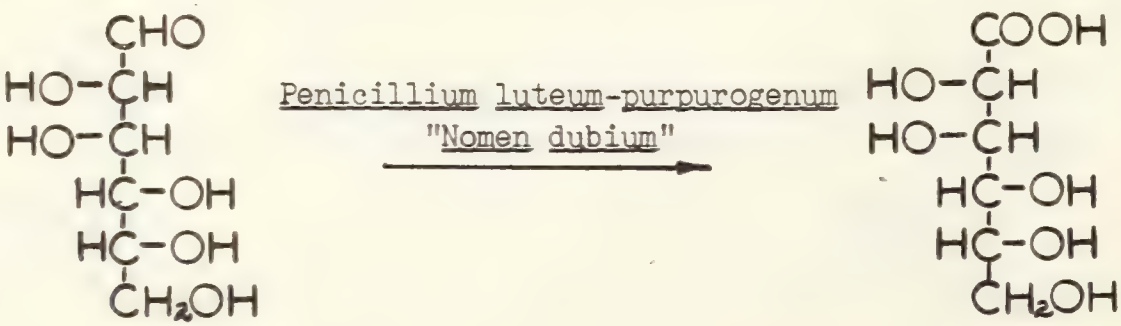
D-xylose

D-xylonic acid

Angeletti and Cerruti, Ann. chim. applicata 20, 424-33 (1930).

C.A. 25, 533[8] (1931).

Rx. 304

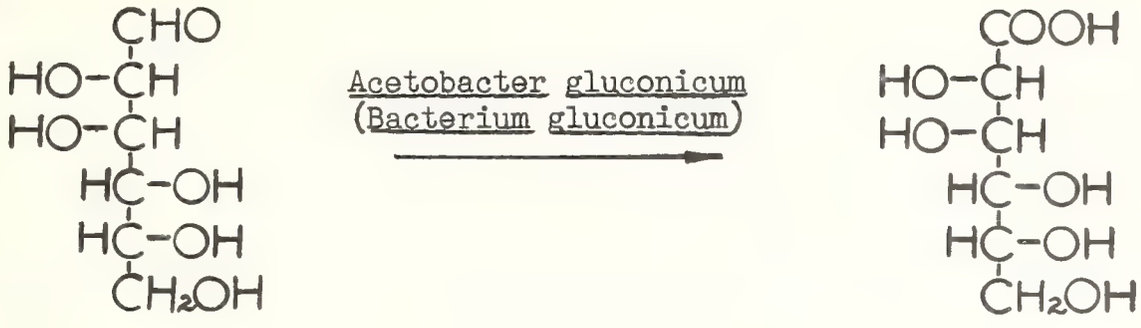


mannose

mannonic acid (9.4%)

Hermann and Neuschul, Bull. soc. chim. biol. 18, 390-4 (1936).
C.A. 30, 4528[9] (1936).

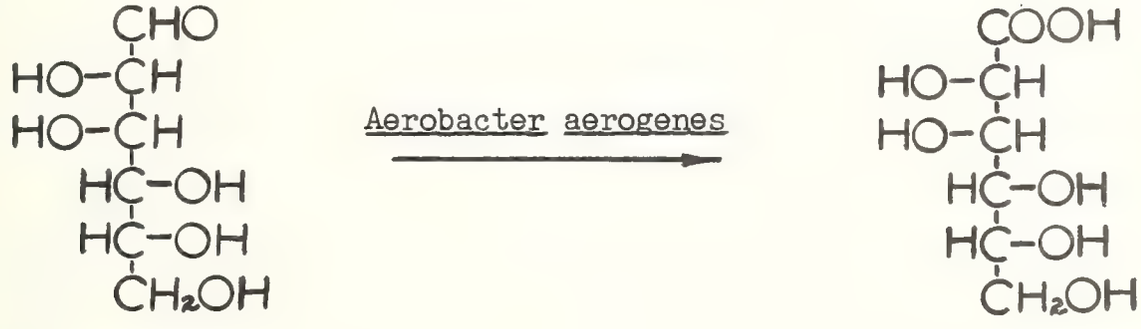
Rx. 305



mannose — mannonic acid (60-70%)

Masuo and Nozaki, Ann. Rept. Shionogi Research Lab. No. 6, 110-14 (1956).
C.A. 51, 5192f (1957).

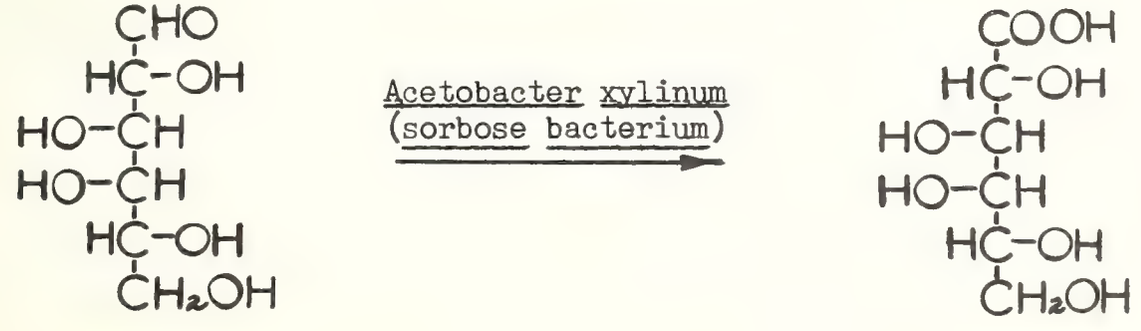
Rx. 306



D-mannose — D-mannonic acid

Bertrand, Compt. rend. 127, 728-30 (1898).
Brit. C.A. 76 /ii/, 170 (1899).

Rx. 307

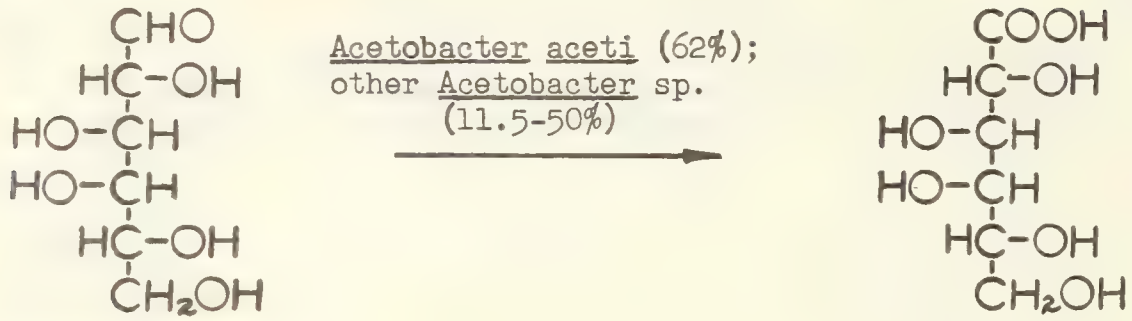


galactose — galactonic acid (approx. 66%)

Hermann and Neuschul, Biochem. Z. 233, 129-216 (1931).

C.A. 25, 3684[3] (1931).

Rx. 308

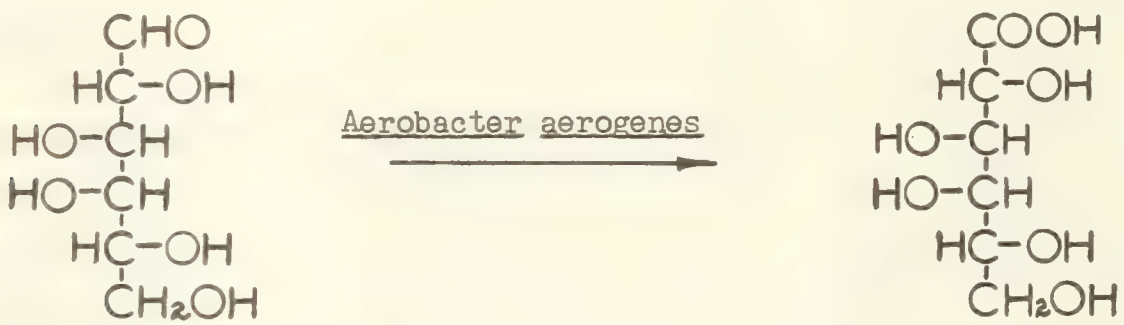


galactose — galactonic acid

Masuo and Nozaki, Ann. Rept. Shionogi Research Lab. No. 6, 110-14 (1956).

C.A. 51, 5192f (1957).

Rx. 309

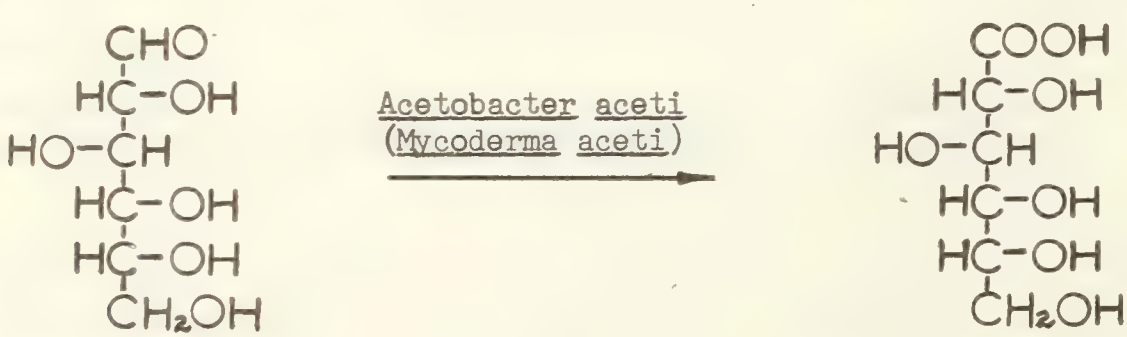


D-galactose — D-galactonic acid

Boutroux, Compt. rend. 91, 236-8 (1880).

Brit. C.A. 38, 863 (1880).

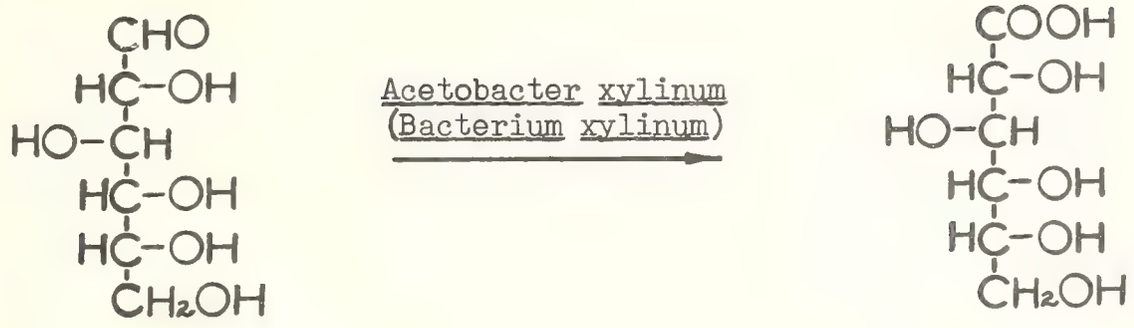
Rx. 310



glucose — gluconic acid

Brown, J. Chem. Soc. 49, 432-9 (1886).

Rx. 311

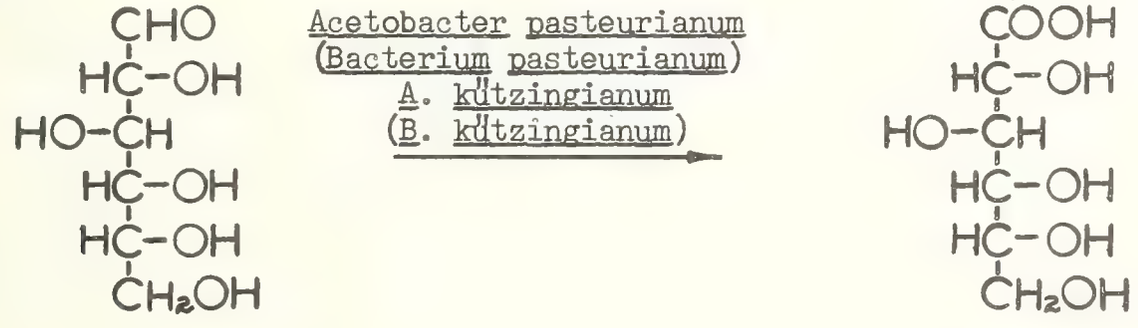


glucose — gluconic acid (approx. 60%)

Seifert, Zentr. Bakt. Parasitenk. /II/ 3, 385-99 (1897).

Brit. C.A. 74 /ii/, 399 (1898).

Rx. 312

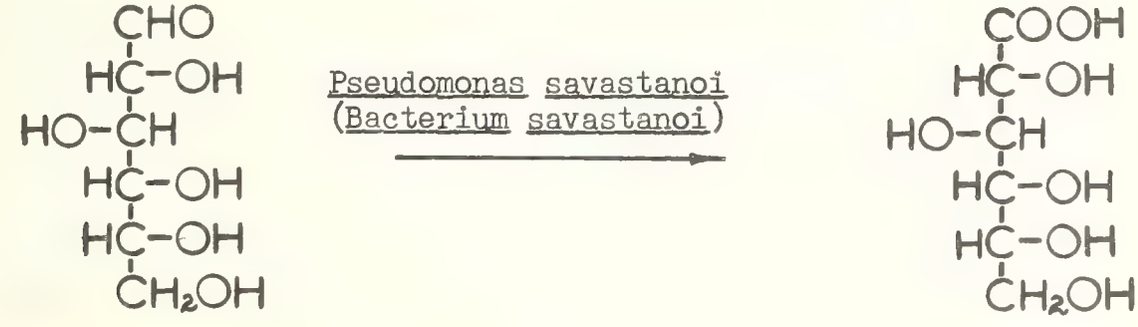


glucose — gluconic acid

Alsberg, J. Biol. Chem. 9, 1-7 (1911).

C.A. 5, 1922[4] (1911).

Rx. 313

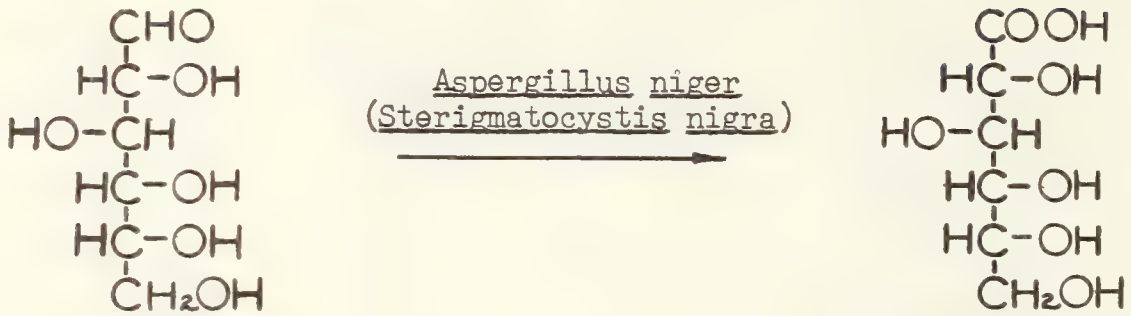


D-glucose — D-gluconic acid

Molliard, Compt. rend. 174, 881-3 (1922).

C.A. 16, 2195[1] (1922).

Rx. 314

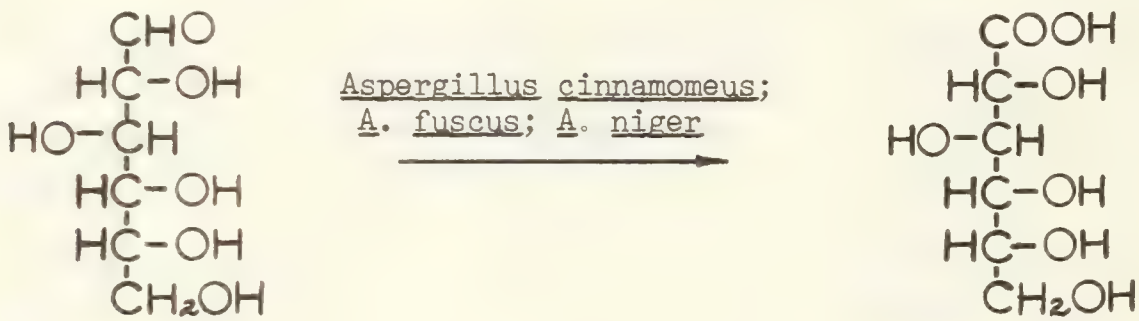


glucose (from sucrose) → gluconic acid

Falck and Kapur, Ber. 57, 920-3 (1924).

C.A. 18, 3044[5] (1924).

Rx. 315

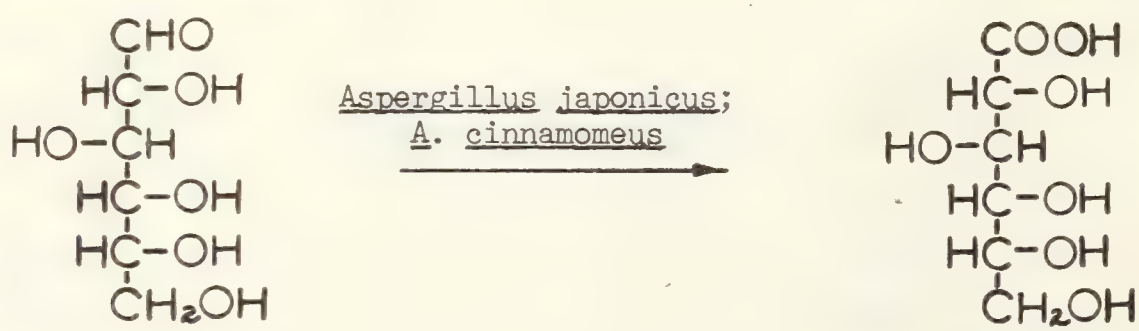


glucose → gluconic acid (26%)

Amelung, Z. physiol. Chem. 166, 161-209 (1927).

C.A. 21, 3212[6] (1927).

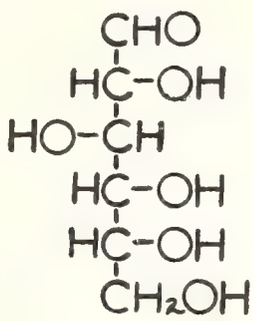
Rx. 316



glucose → gluconic acid (23%)

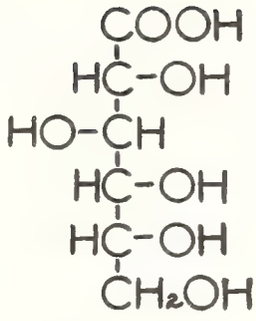
May et al., J. Biol. Chem. 75, 417-22 (1927).
C.A. 22, 794[6] (1928).

Rx. 317



D-glucose

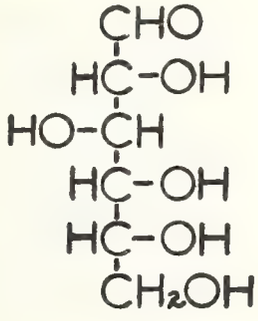
Penicillium luteum purpurogenum;
"Nomen dubium"
other Penicillium sp.



D-gluconic acid (20-60%)

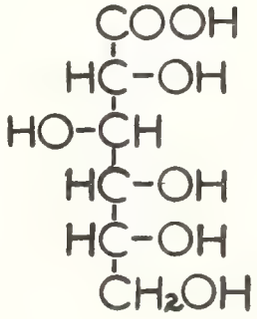
Herrick and May, U. S. 1,726,067 (Aug. 27, 1929).
C.A. 23, 5004[3] (1929).

Rx. 318



glucose

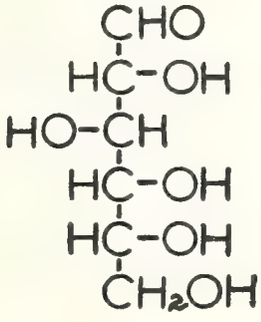
Penicillium citrinum;
Pen. divaricatum;
Pen. luteum purpurogenum
"Nomen dubium"



gluconic acid

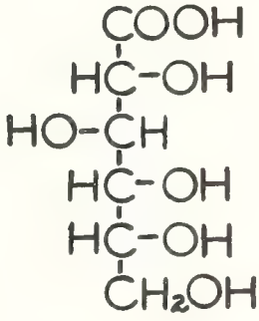
Sumiki, J. Agr. Chem. Soc. Japan 6, 17-22 (1930).
C.A. 24, 3811[9] (1930).

Rx. 319



glucose

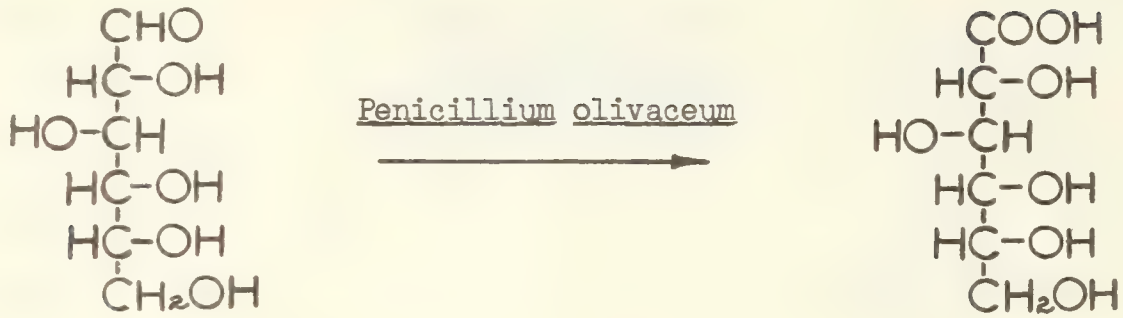
Aspergillus glaucus



gluconic acid (72%)

Sumiki, J. Agr. Chem. Soc. Japan 6, 23-7 (1930).
C.A. 24, 3812[1] (1930).

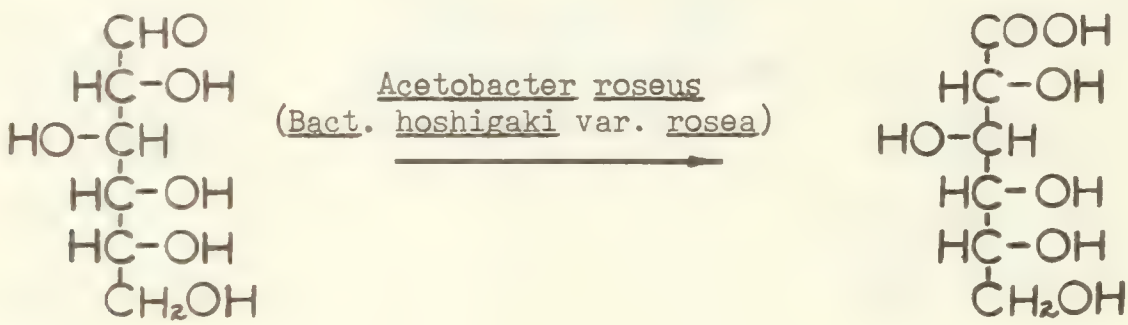
Rx. 320



glucose — gluconic acid

Takahashi and Asai, J. Agr. Chem. Soc. Japan 6, 223-41 (1930).
C.A. 24, 4318[9] (1930).

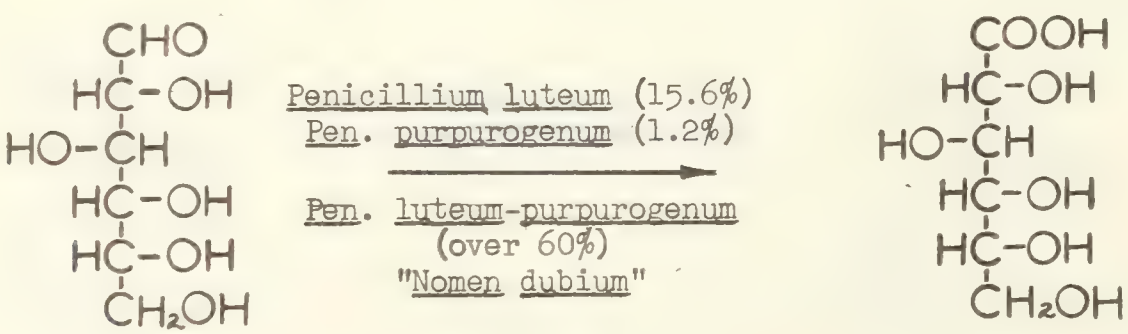
Rx. 321



glucose — gluconic acid (80-100%)

Angeletti and Cerruti, Ann. chim. applicata 20, 424-33 (1930).
C.A. 25, 533[8] (1931).

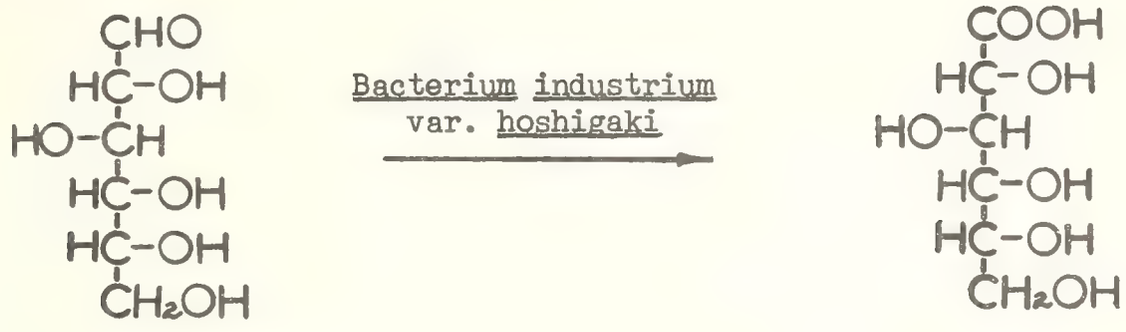
Rx. 322



glucose — gluconic acid

Takahashi and Asai, J. Agr. Chem. Soc. Japan 6, 526-37 (1930).
C.A. 24, 4319[2] (1930).

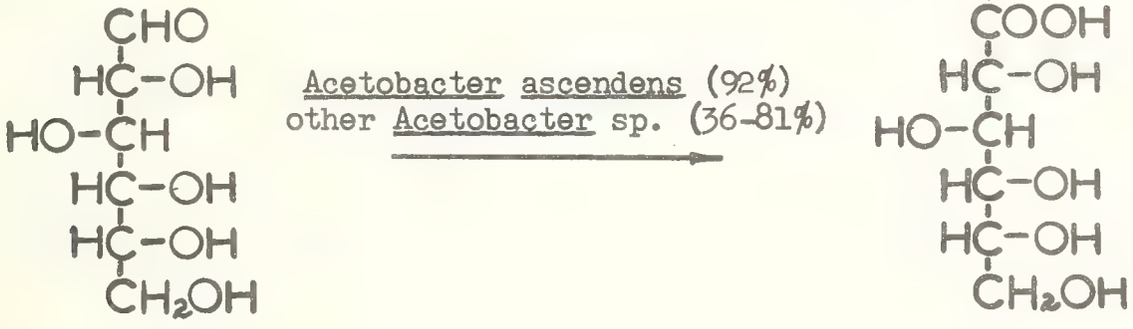
Rx. 323



glucose — gluconic acid

Hermann and Neuschul, Biochem. Z. 233, 129-216 (1931).
C.A. 25, 3684[3] (1931).

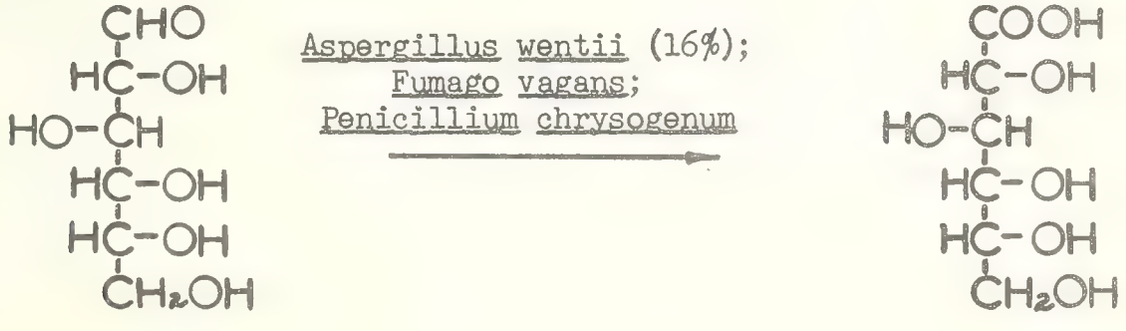
Rx. 324



glucose — gluconic acid

Birkinshaw and Raistrick, Trans. Roy. Soc. (London) B220, 331-53 (1931).
C.A. 26, 2487[2] (1932).

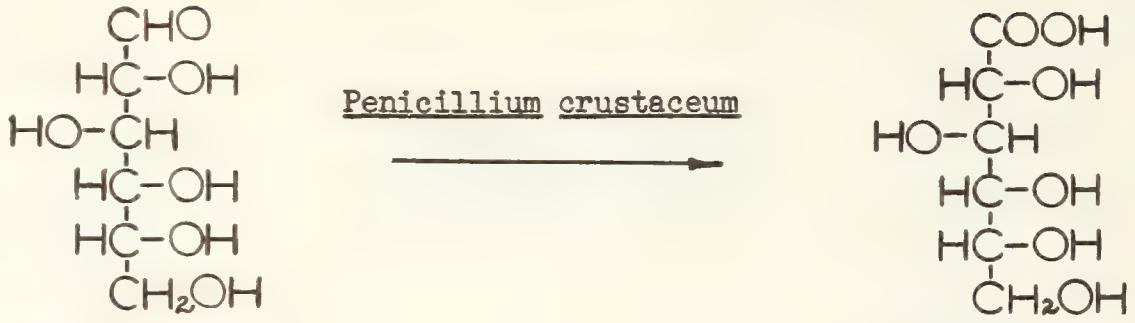
Rx. 325



glucose — gluconic acid

Angeletti, Ann. chim. applicata 22, 59-62 (1932).
C.A. 26, 3540[3] (1932).

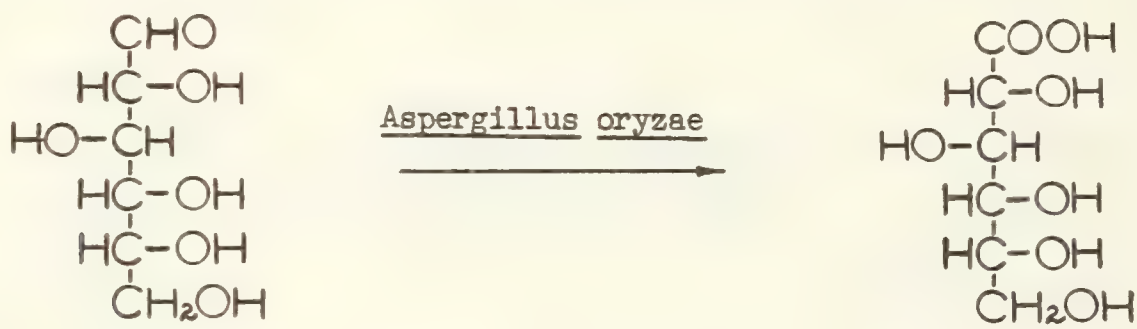
Rx. 326



glucose — gluconic acid (12%)

Sakaguchi, J. Agr. Chem. Soc. Japan 8, 264-5 (1932).
C.A. 27, 1379[8] (1933).

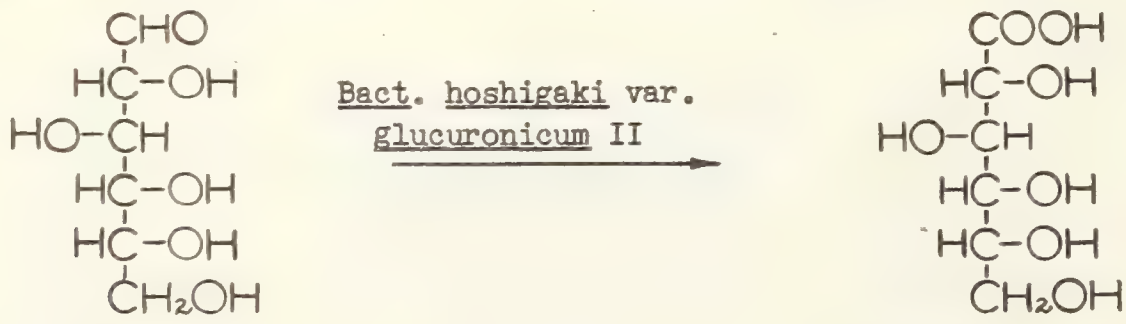
Rx. 327



glucose — gluconic acid (88%)

Takahashi and Asai, J. Agr. Chem. Soc. Japan 8, 703-19 (1932).
C.A. 26, 5602[3] (1932).

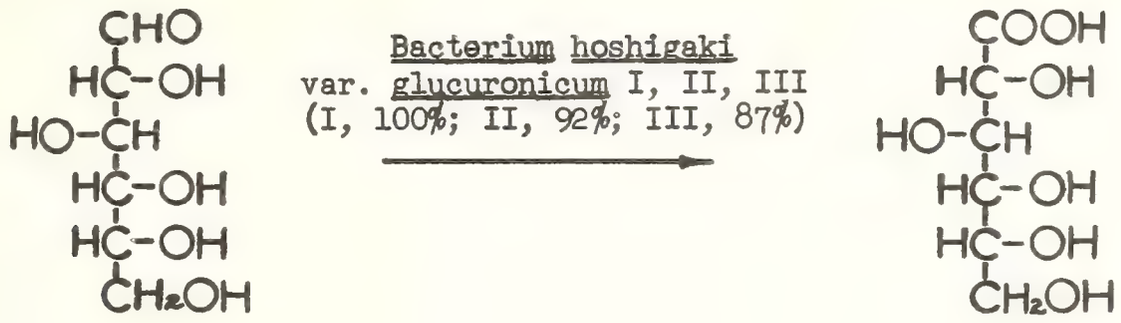
Rx. 328



glucose — gluconic acid (89%)

Takahashi and Asai, Zentr. Bakt. Parasitenk. II Abt. 87, 385-412 (1933). C.A. 27, 1981[2] (1933).

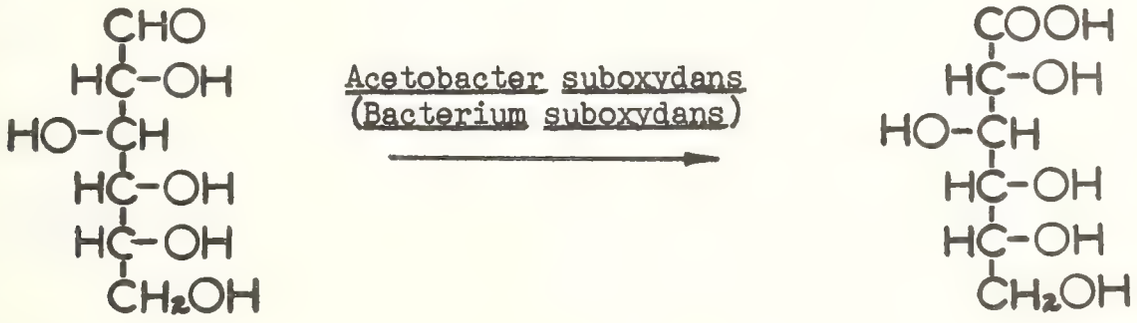
Rx. 329



glucose — gluconic acid

Butlin, Biochem. J. 30, 1870-7 (1936). See J. Soc. Chem. Ind. 58, 363-5 (1939). C.A. 31, 1842[1] (1937).

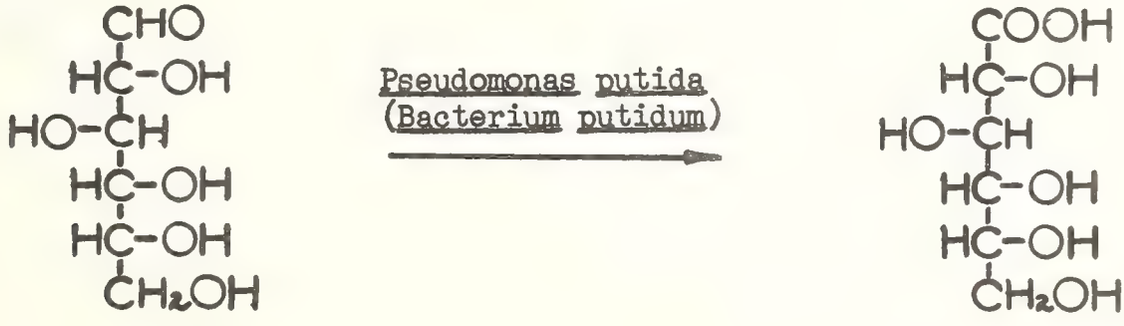
Rx. 330



glucose — gluconic acid

Pervozvanskiĭ and Ivashkevich, Microbiology (U.S.S.R) 8, No. 3-4, 339-52 (1939). C.A. 34, 7321[7] (1940).

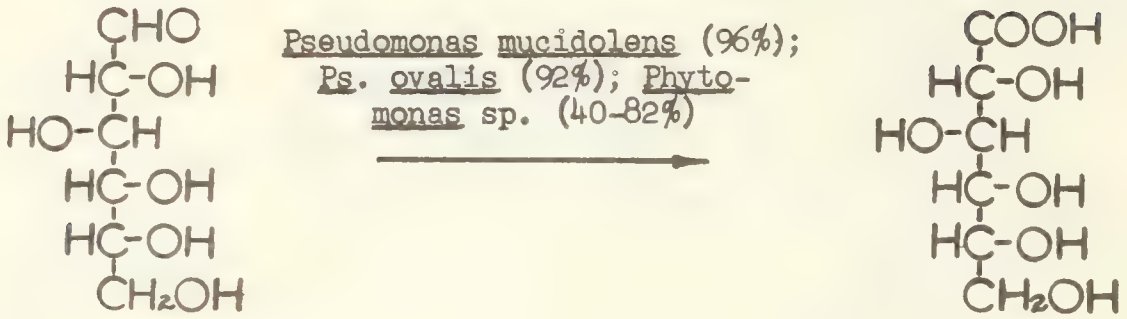
Rx. 331



glucose — gluconic acid

Lockwood et al., J. Bacteriol. 42, 51-61 (1941).
C.A. 35, 7449[9] (1941).

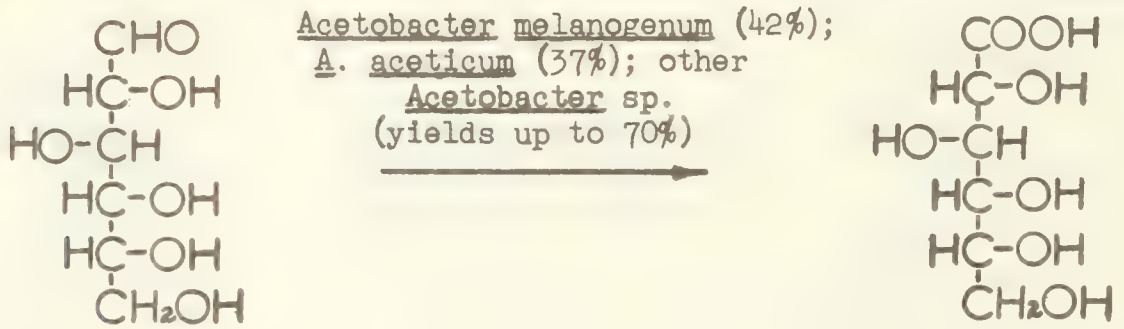
Rx. 332



glucose — gluconic acid

Porges et al., Iowa State Coll. J. Sci. 16, 451-69 (1942).
C.A. 36, 5198[8] (1942).

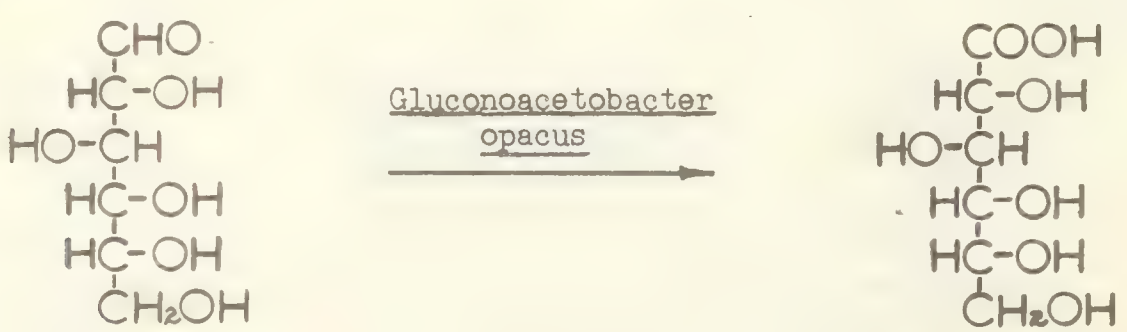
Rx. 333



glucose — gluconic acid

Sakaguchi et al., J. Agr. Chem. Soc. Japan 20, 155-8 (1944).
C.A. 42, 5508e (1948).

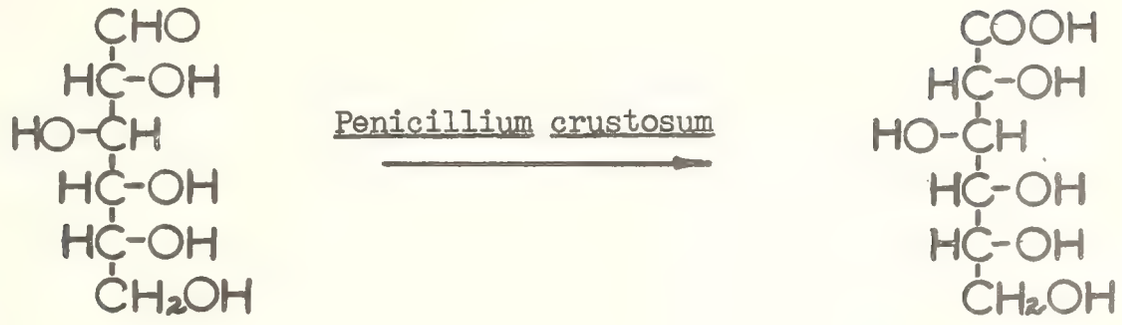
Rx. 334



glucose — gluconic acid

Utkin, Mikrobiologiya 15, 211-21 (1946).
C.A. 42, 8877f (1948).

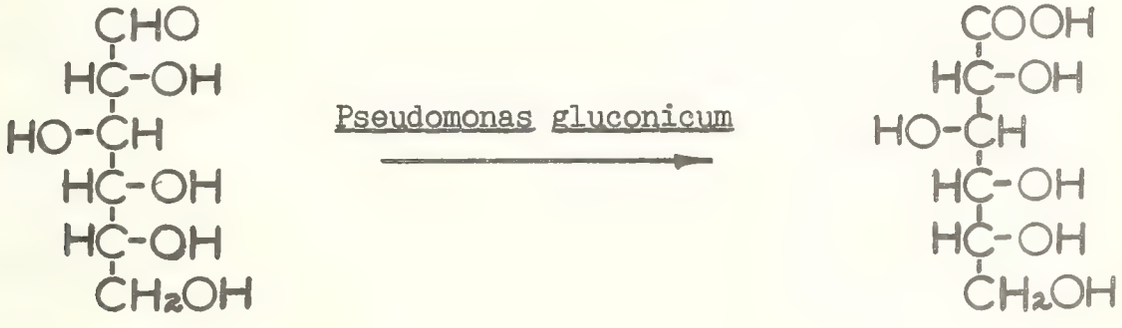
Rx. 335



glucose — gluconic acid

Ikeda, J. Agr. Chem. Soc. Japan 24, 51-5 (1950).
C.A. 45, 7189f (1951).

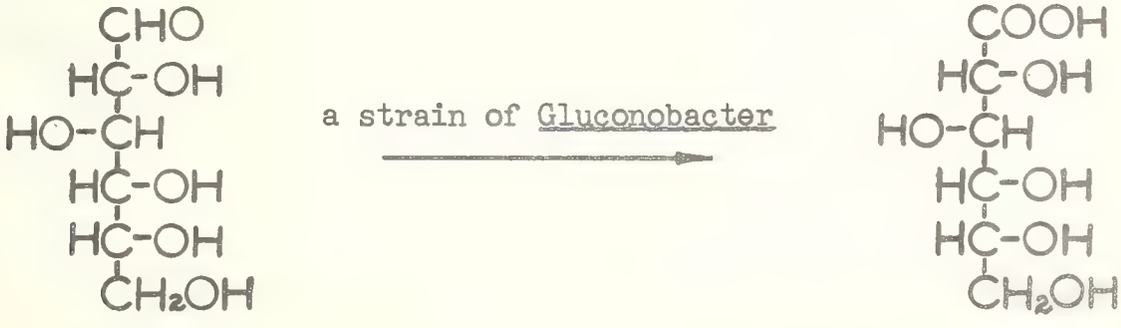
Rx. 336



glucose — gluconic acid

Katagiri and Itagaki, Bull. Inst. Chem. Research, Kyoto Univ. 22, 94-5 (1950).
C.A. 45, 4399d (1951).

Rx. 337

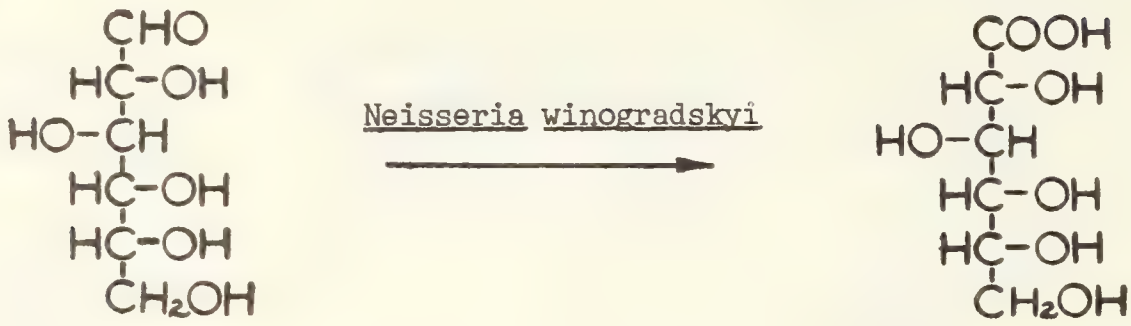


glucose — gluconic acid

Lemoigne and Croson, Compt. rend. 235, 1075-8 (1952).

C.A. 47, 4381h (1953).

Rx. 338

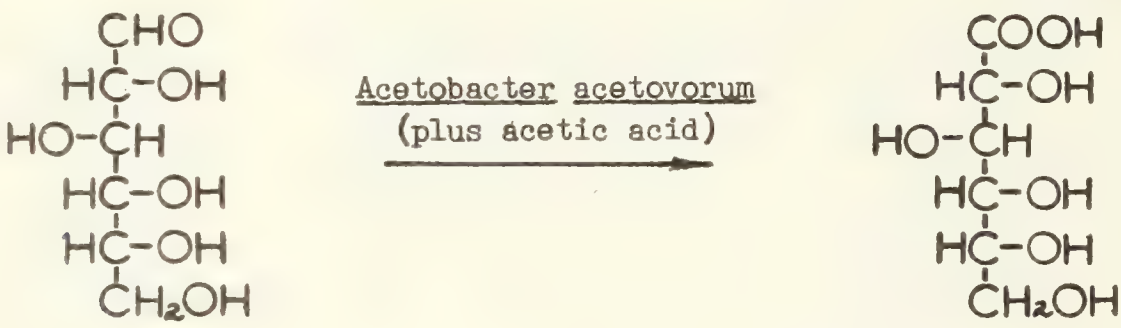


glucose — gluconic acid

Loĭtsyanskaya, Mikrobiologiya 22, 263-6 (1953).

C.A. 47, 12523i (1953).

Rx. 339

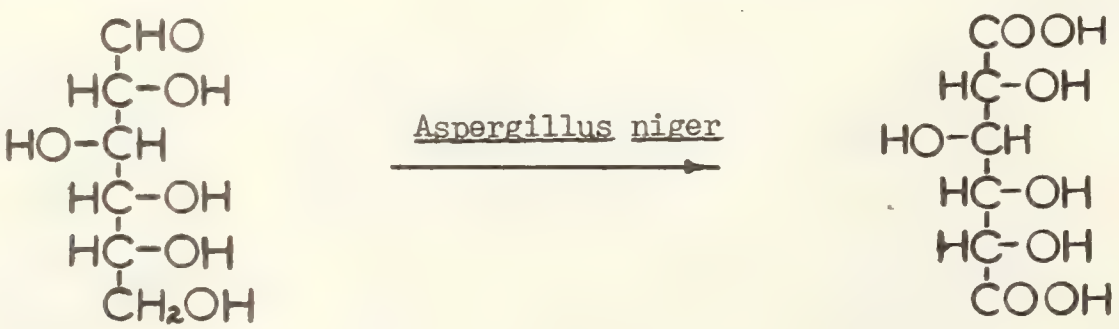


glucose — gluconic acid

Challenger et al., Nature 119, 674 (1927).

C.A. 21, 2715[3] (1927).

Rx. 340

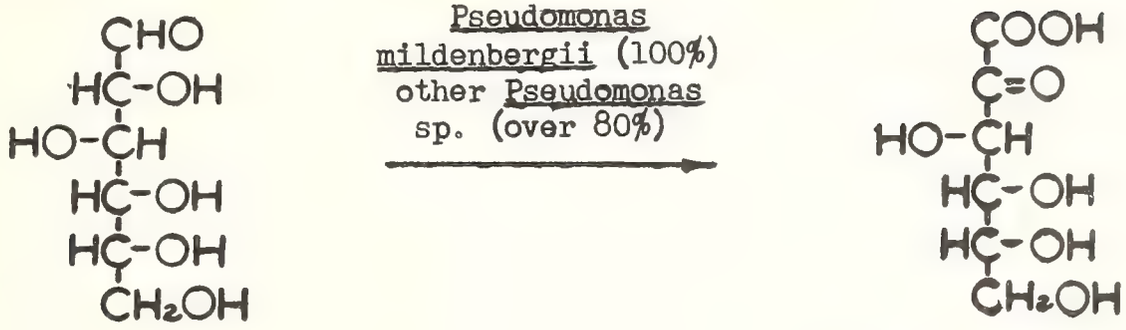


glucose — saccharic acid

Lockwood et al., J. Bacteriol. 42, 51-61 (1941).

C.A. 35, 7449[9] (1941).

Rx. 341



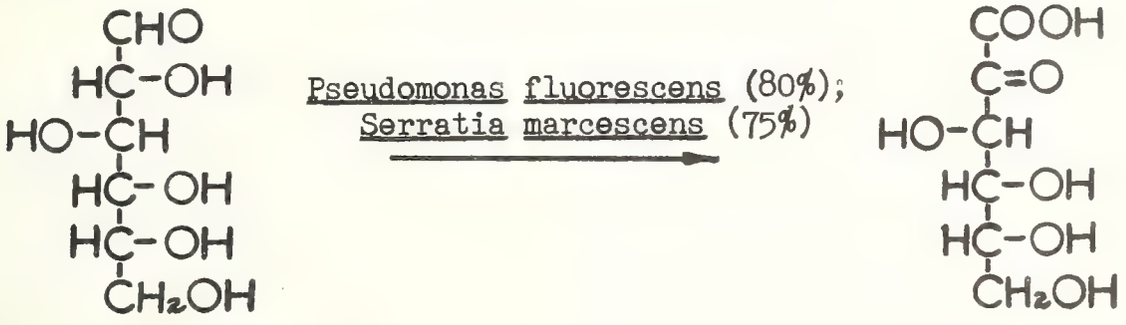
D-glucose

2-keto-D-gluconic acid

Ikeda, J. Agr. Chem. Soc. Japan 24, 56-9 (1950).

C.A. 45, 7189g (1951).

Rx. 342

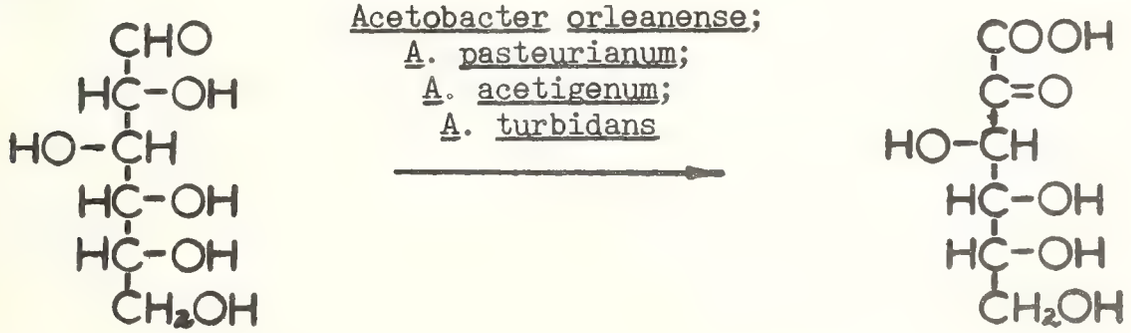


glucose

2-ketogluconic acid

Kulka et al., Nature 167, 905-6 (1951).

Rx. 343

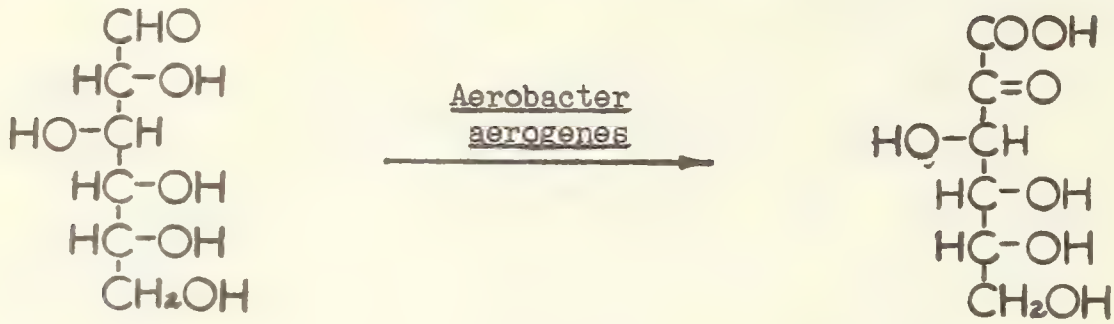


D-glucose

2-keto-D-gluconic acid

Masuo and Nozaki, Ann. Repts. Shionogi Research Lab. No. 3, 97-101 (1953).
C.A. 50, 15711g (1956).

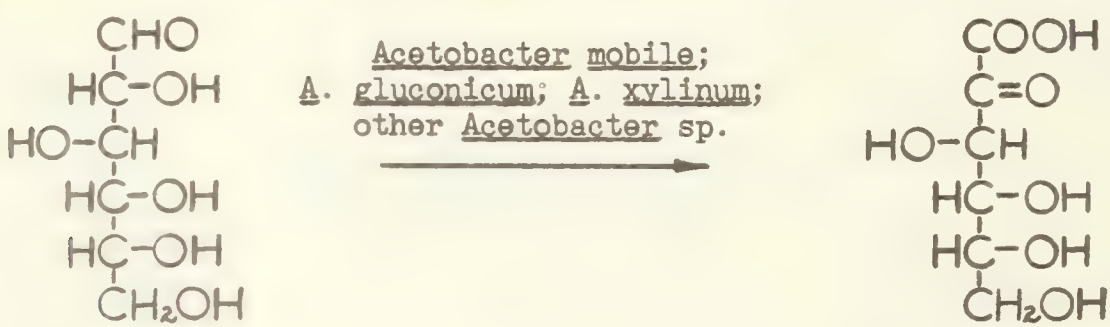
Rx. 344



D-glucose — 2-keto-D-gluconic acid

Kulka and Walker, Arch. Biochem. Biophys. 50, 169-79 (1954).
C.A. 48, 8870f (1954).

Rx. 345



glucose — 2-ketogluconic acid

Blackwood and Blakley, Can. J. Microbiol. 2, 741-6 (1956).
C.A. 51, 2942b (1957).

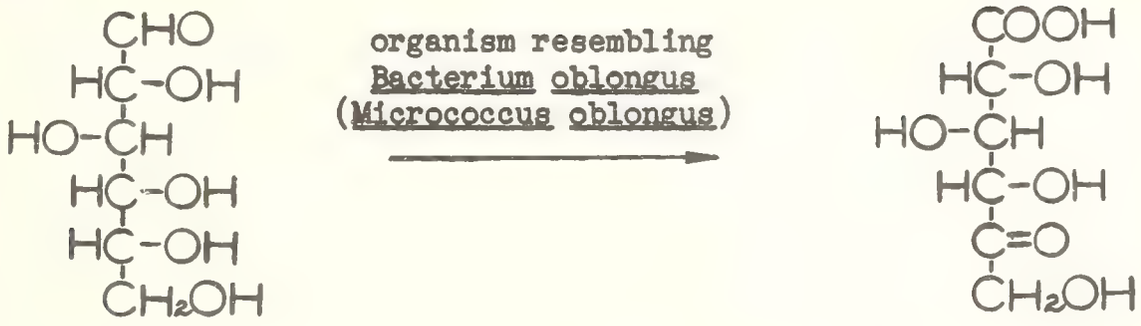
Rx. 346

D-glucose — 2-keto-D-gluconic acid

Boutroux, Compt. rend. 102, 924-7 (1886). See ibid. 111, 185-7 (1890).

Brit. C.A. 50 [ii],682 (1886).

Rx. 347



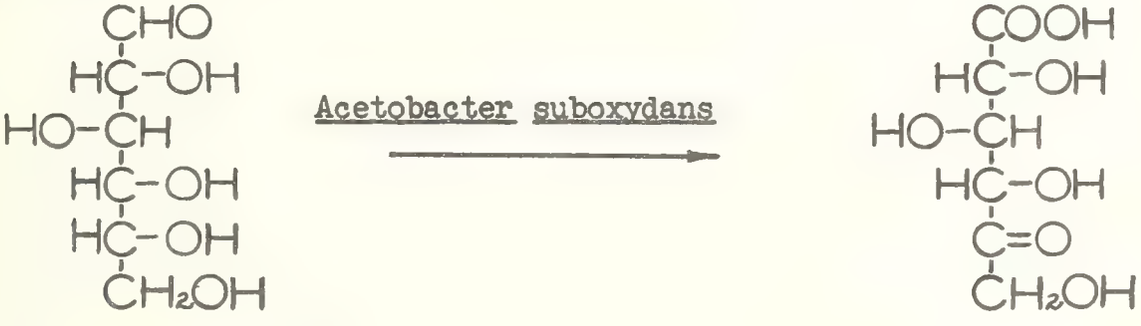
glucose

"oxygluconic acid"
(probably 5-ketogluconic acid)

Kluyver and de Leeuw, Tijdschr. vergelijk. Geneeskunde 10, 170-82 (1924).

C.A. 18, 3202[6] (1924).

Rx. 348

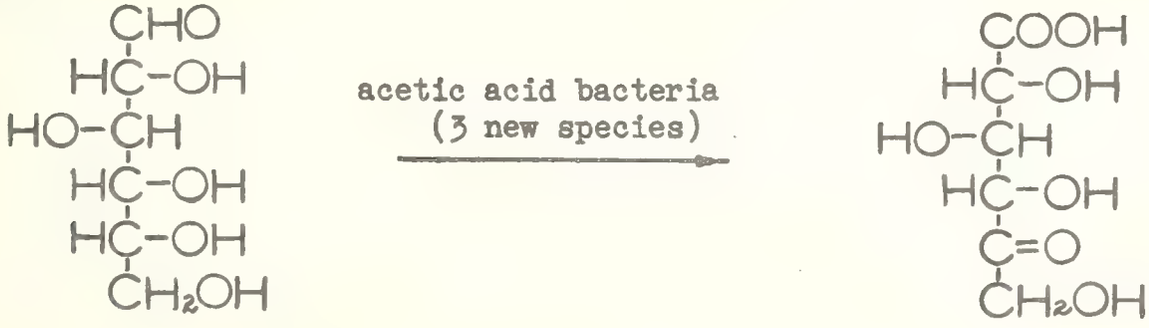


glucose

"oxygluconic acid"
(shown later to be 5-ketogluconic acid)

Takahashi and Asai, J. Agr. Chem. Soc. Japan 6, 407-12 (1930).
C.A. 24, 4319[1] (1930).

Rx. 349

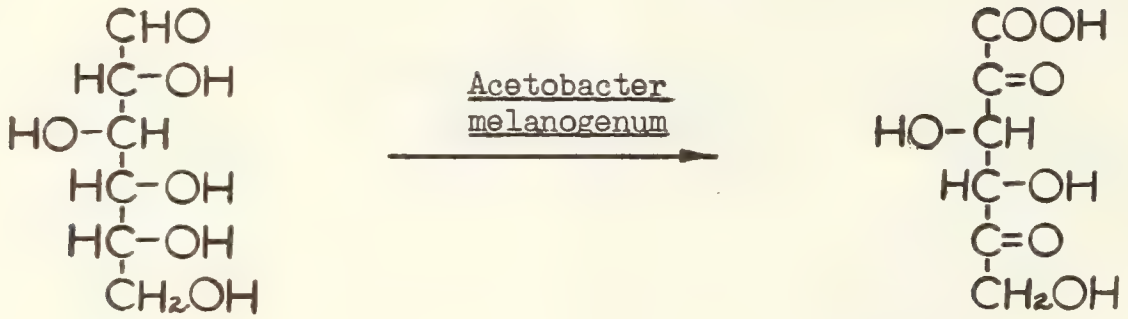


glucose

5-ketogluconic acid

Katznelson et al., J. Biol. Chem. 204, 43-59 (1953).
C.A. 47, 12520h (1953).

Rx. 350



glucose — 2,5-diketogluconic acid

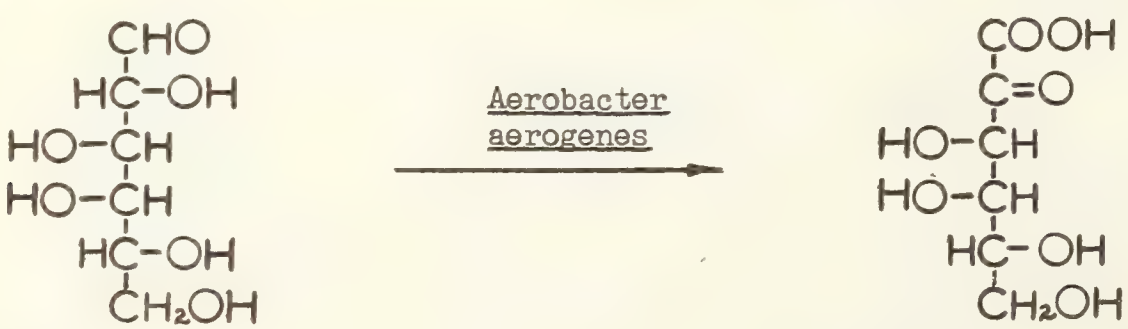
Asai et al., J. Agr. Chem. Soc. Japan 26, 625-30 (1952).
C.A. 48, 12882f (1954).

Rx. 351

galactose — 2-ketogalactonic acid

Masuo and Nozaki, Ann. Rept. Shionogi Research Lab. No. 6, 110-14 (1956).
C.A. 51, 5192f (1957).

Rx. 352

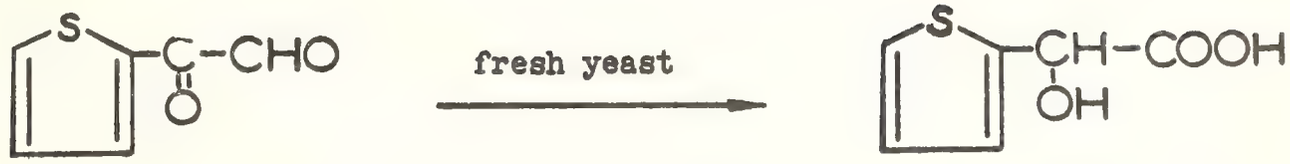


D-galactose — 2-keto-D-galactonic acid

Fujise, Biochem. Z. 236, 241-6 (1931).

C.A. 25, 4898[3] (1931).

Rx. 353



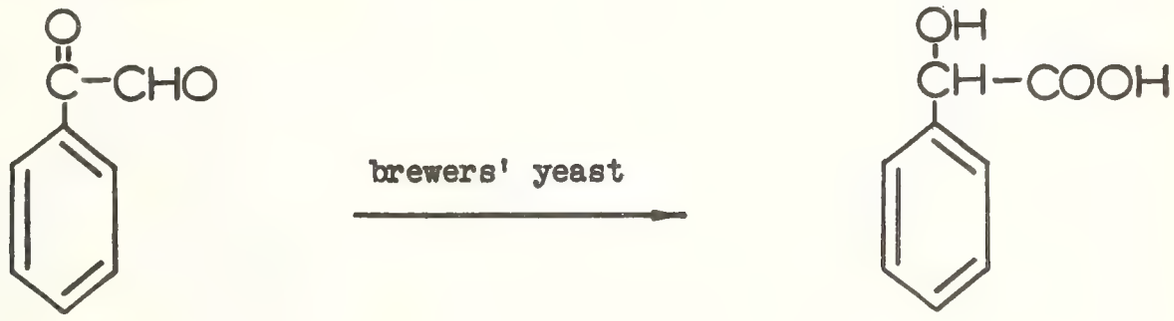
α-thienylglyoxal

α-thienylglycolic acid
(nearly 100%)

Dakin, J. Biol. Chem. 18, 91-3 (1914).

C.A. 8, 2737[8] (1914).

Rx. 354



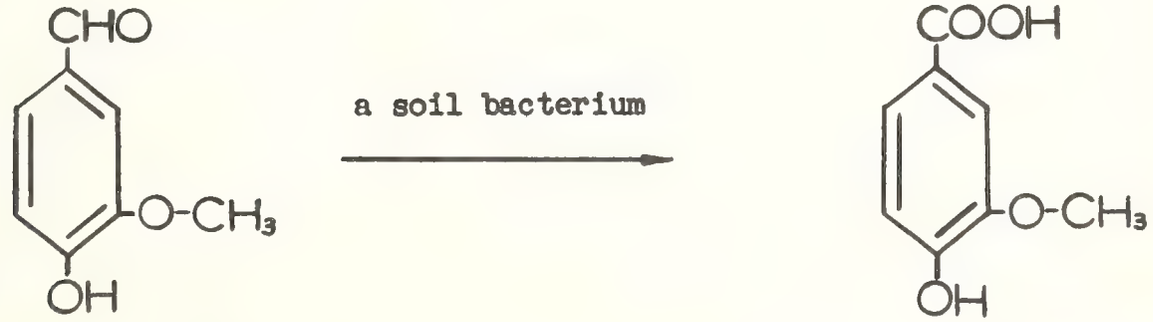
phenylglyoxal

l-mandelic acid
(approx. 26%)

Robbins and Lathrop, Soil Sci. 7, 475-85 (1919).

C.A. 14, 445[1] (1920).

Rx. 355



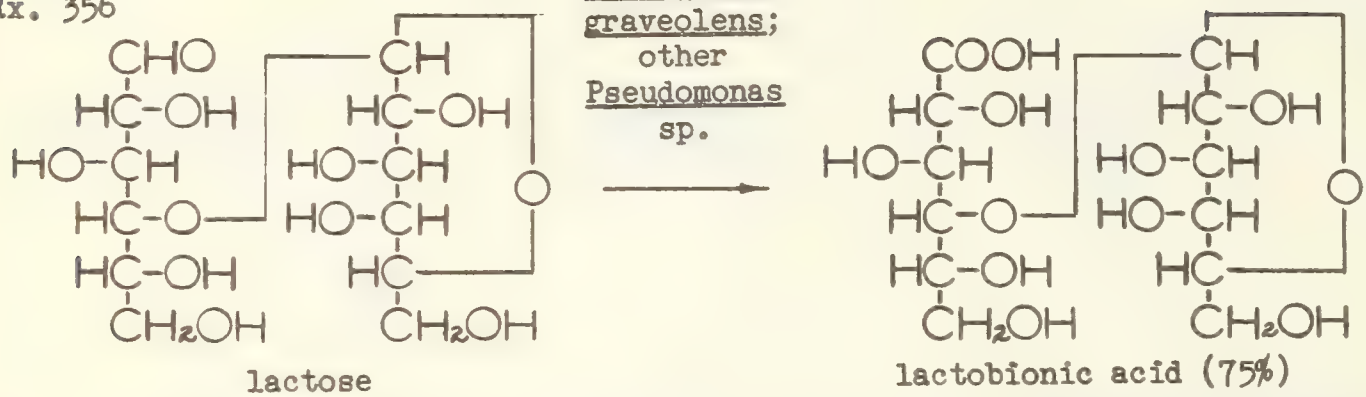
vanillin
(3-methoxy-4-hydroxybenzaldehyde)

vanillic acid

Stodola and Lockwood, J. Biol. Chem. 171, 213-21 (1947).

C.A. 42, 1983h (1948).

Rx. 356



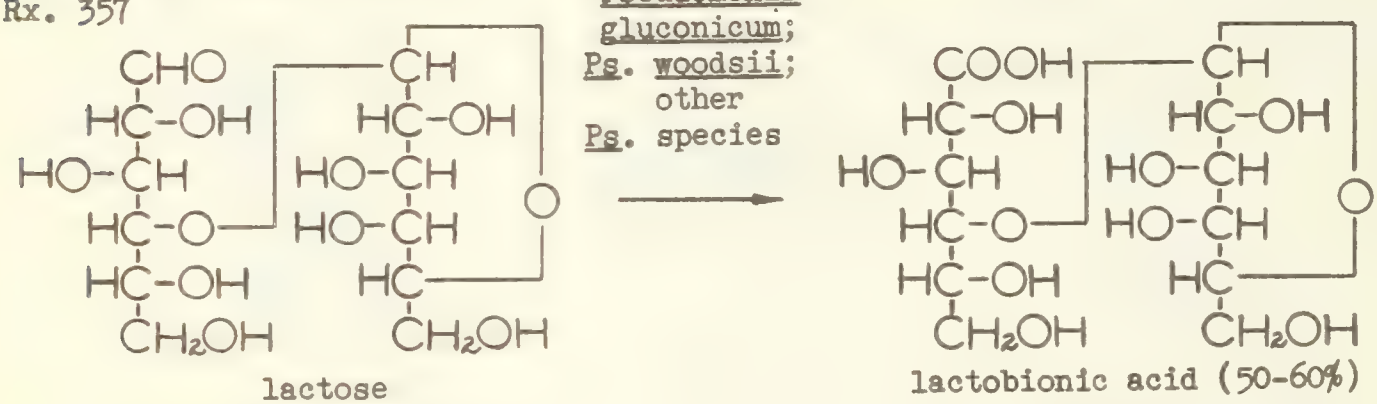
lactose → lactobionic acid (75%)

See Kluyver, A. J. et al., Antonie van Leeuwenhoek J. Microbiol. Serol. 17, 1-14 (1951) for other Pseudomonas spp.

Masuo et al., Ann. Repts. Shionogi Research Lab. No. 1, 136-41 (1952).

C.A. 51, 12231d (1957).

Rx. 357

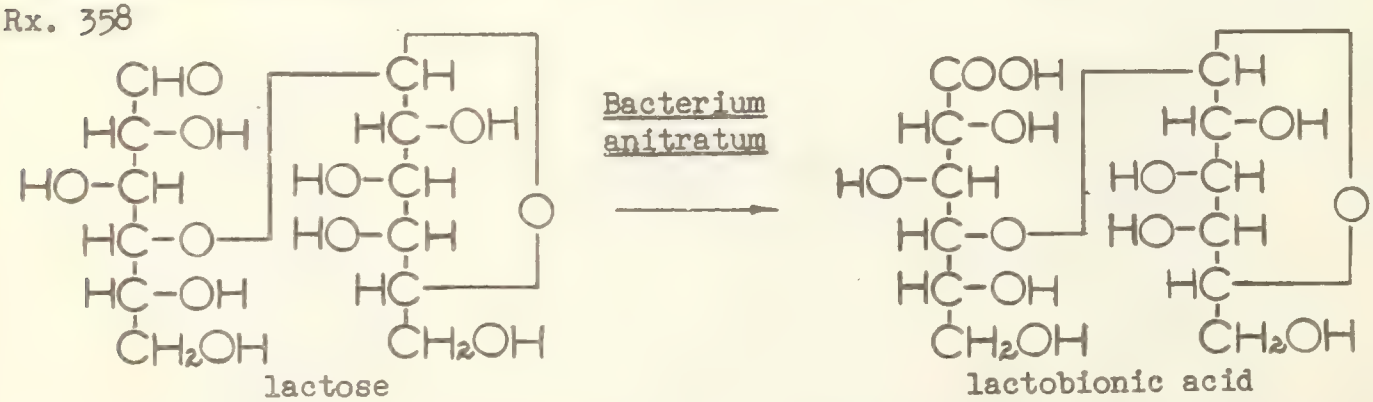


lactose → lactobionic acid (50-60%)

Villecourt and Blachère, Ann. inst. Pasteur 88, 523-6 (1955).

C.A. 49, 10419h (1955).

Rx. 358

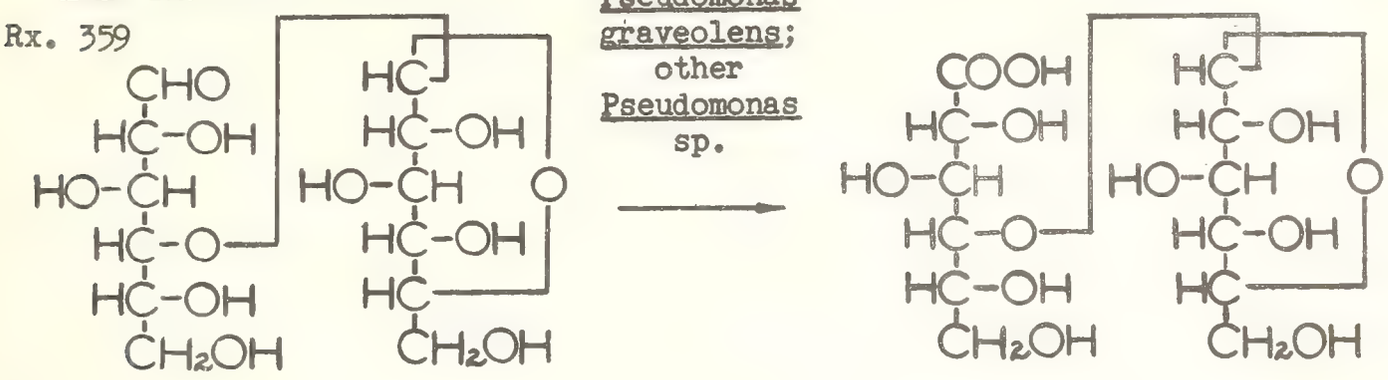


lactose → lactobionic acid

Stodola and Lockwood, J. Biol. Chem. 171, 213-21 (1947). See ref. to Kluyver, A. J. et al. in Rx. 356

C.A. 42, 1983h (1948).

Rx. 359



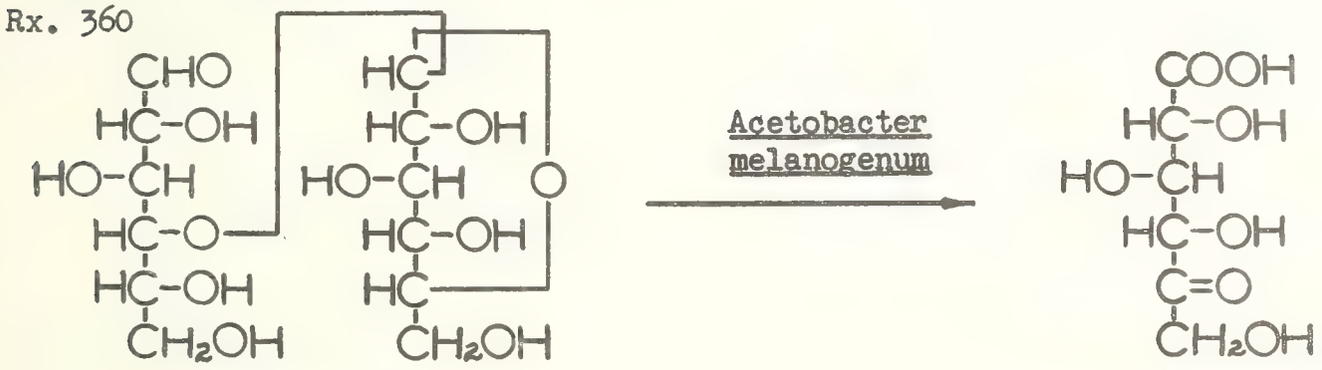
maltose

maltobionic acid (77%)

Foda and Vaughn, J. Bacteriol. 65, 233-7 (1953).

C.A. 47, 5990d (1953).

Rx. 360



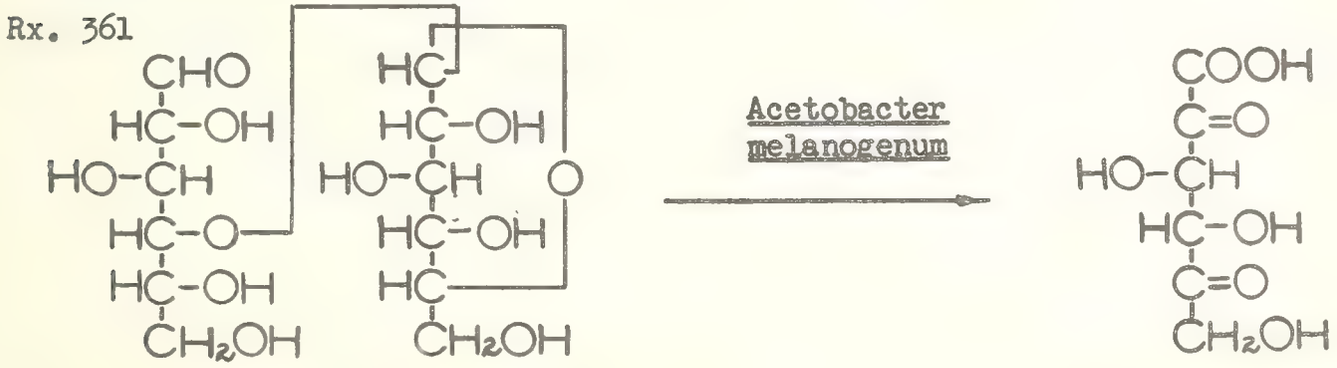
maltose

5-ketogluconic acid

Katznelson and Tanenbaum, J. Bacteriol. 68, 368-72 (1954).

C.A. 48, 13813a (1954).

Rx. 361



maltose

2,5-diketogluconic acid

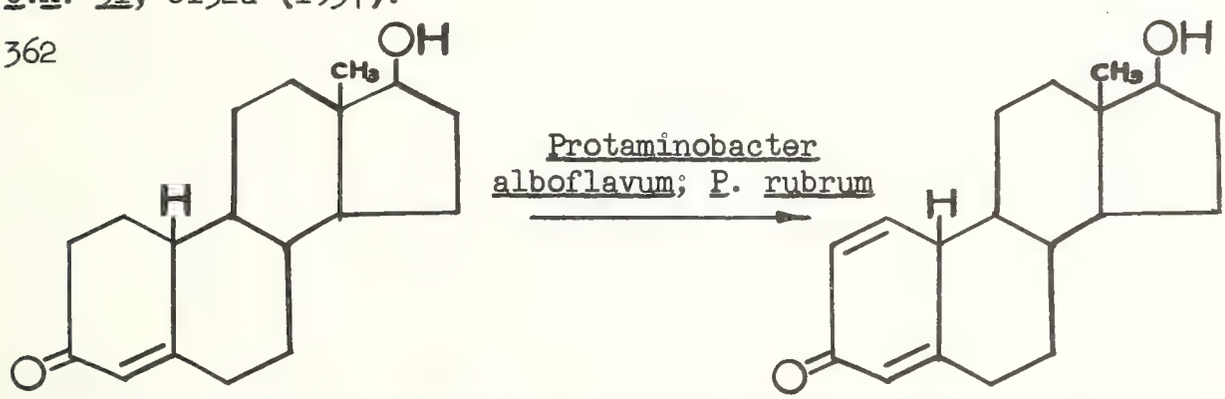
I. Oxidation

d. $-CH_2-CH_2- \longrightarrow -CH=CH-$

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 362



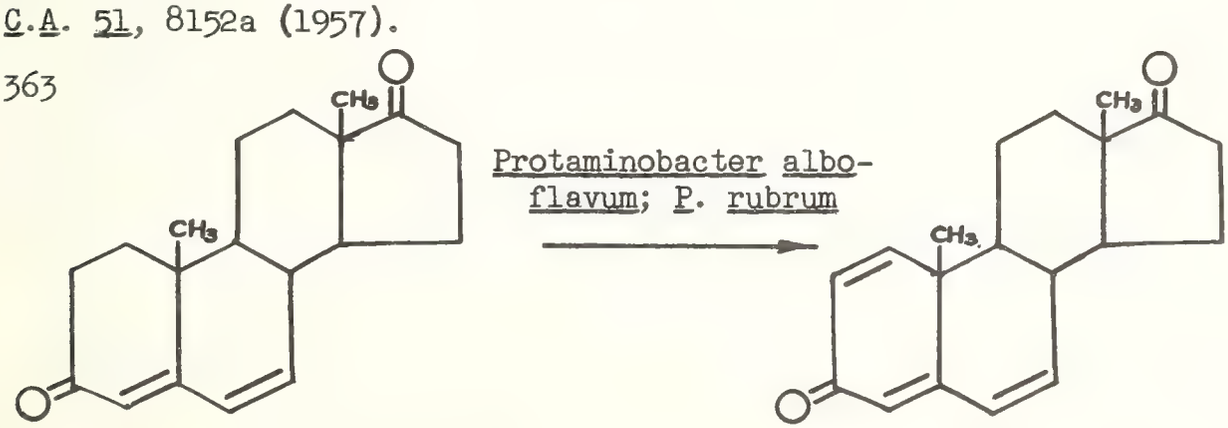
19-nortestosterone

Δ^1-dehydro-19-nortestosterone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 363



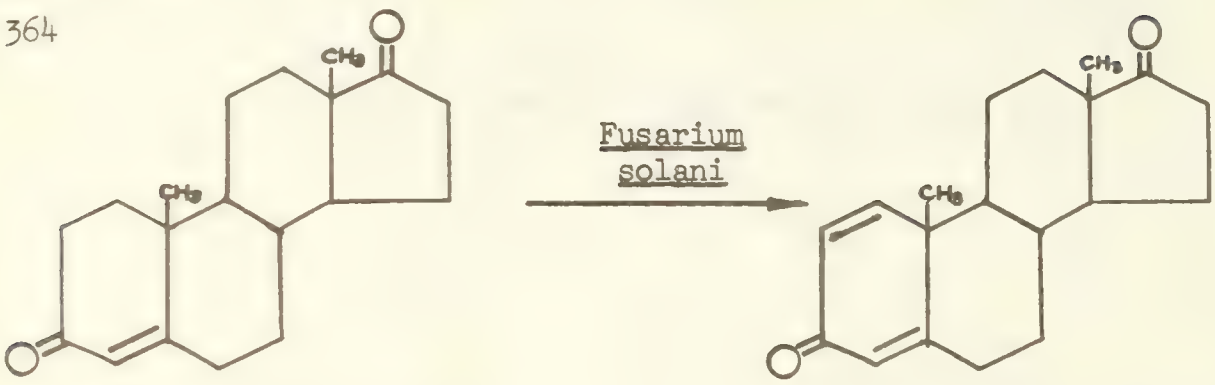
$\Delta^{4,6}$-androstadiene-3,17-dione

$\Delta^{1,4,6}$-androstatriene-3,17-dione

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 364



Δ^4-androstene-3,17-dione

$\Delta^{1,4}$-androstadiene-3,17-dione (nearly 100%)

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 365

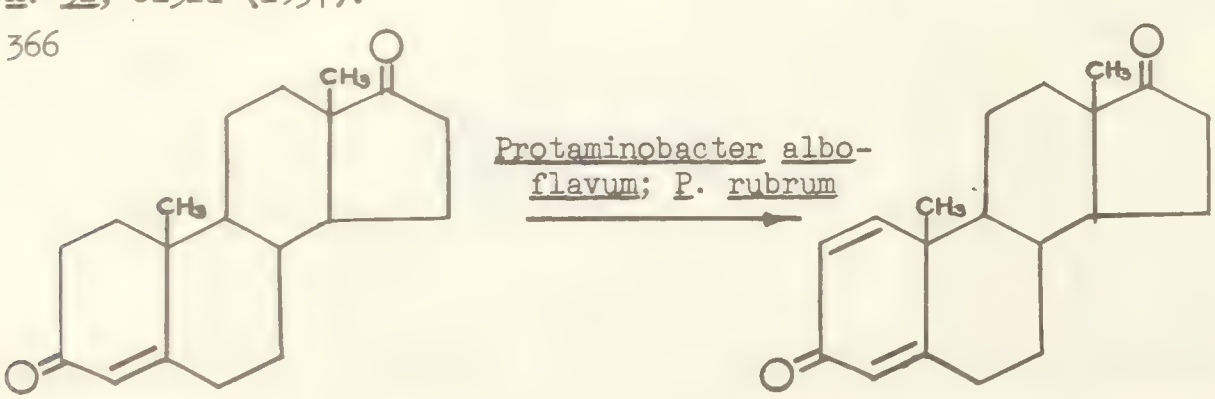
Δ^4-androstene-3,17-dione

$\Delta^{1,4}$-androstadiene-3,17-dione

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 366



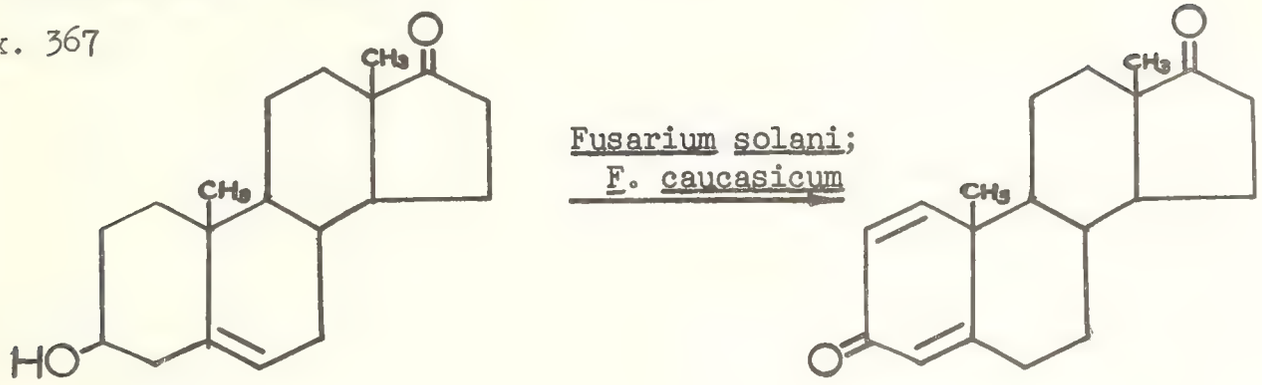
Δ^4-androstene-3,17-dione

$\Delta^{1,4}$-androstadiene-3,17-dione

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 367



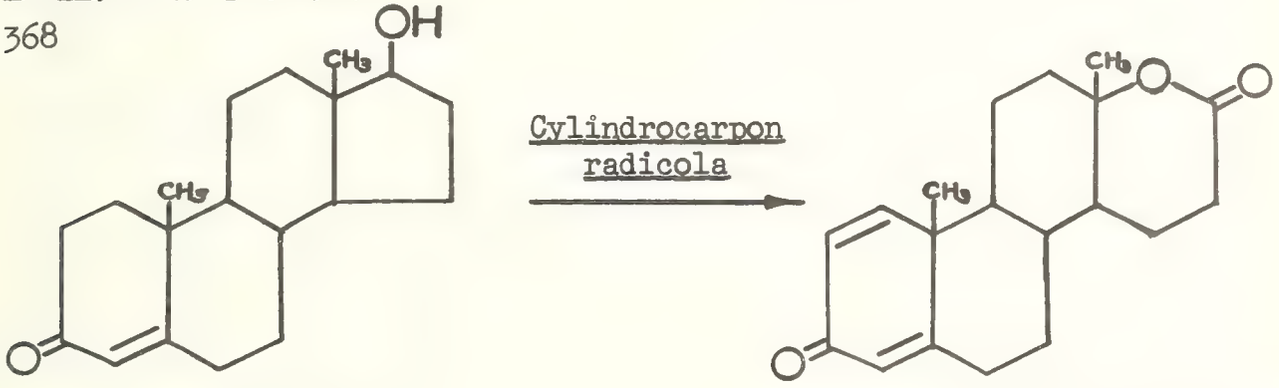
Δ^5-dehydroisoandrosterone

$\Delta^{1,4}$-androstadiene-3,17-dione

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 368



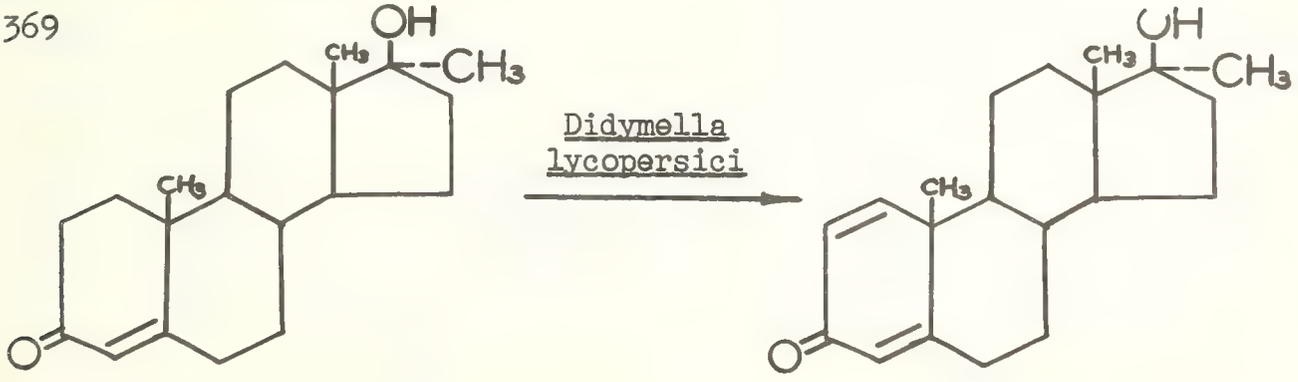
testosterone

Δ^1-dehydrotestololactone (50%)

Vischer et al., Helv. Chim. Acta 38, 1502-7 (1955).

C.A. 50, 5716a (1956).

Rx. 369

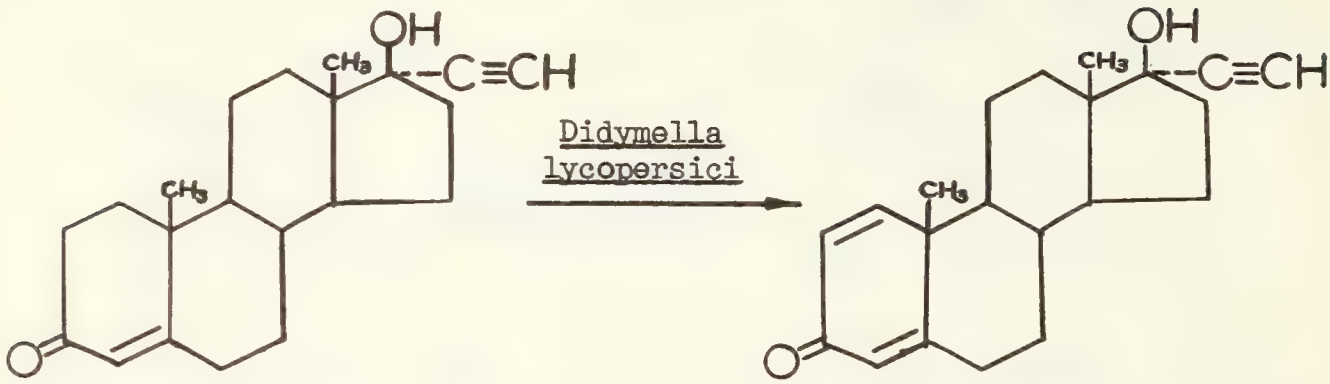


17α-methyltestosterone

Δ^1-dehydro-17α-methyltestosterone

Vischer et al., Helv. Chim. Acta 38, 1502-7 (1955).
C.A. 50, 5716a (1956).

Rx. 370

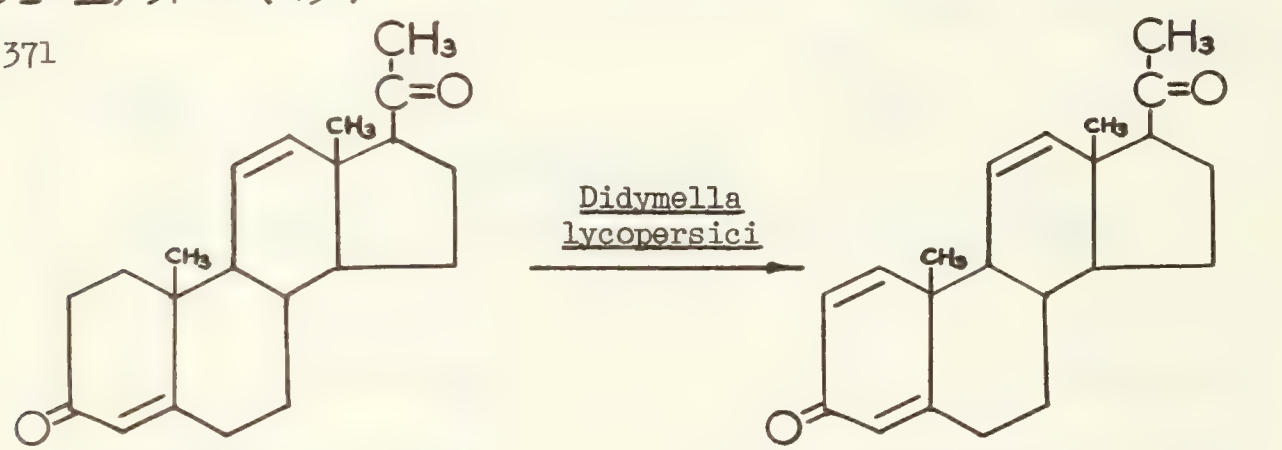


17α-ethinyltestosterone

Δ^1-dehydro-17α-ethinyl-testosterone

Vischer et al., Helv. Chim. Acta 38, 1502-7 (1955).
C.A. 50, 5716a (1956).

Rx. 371

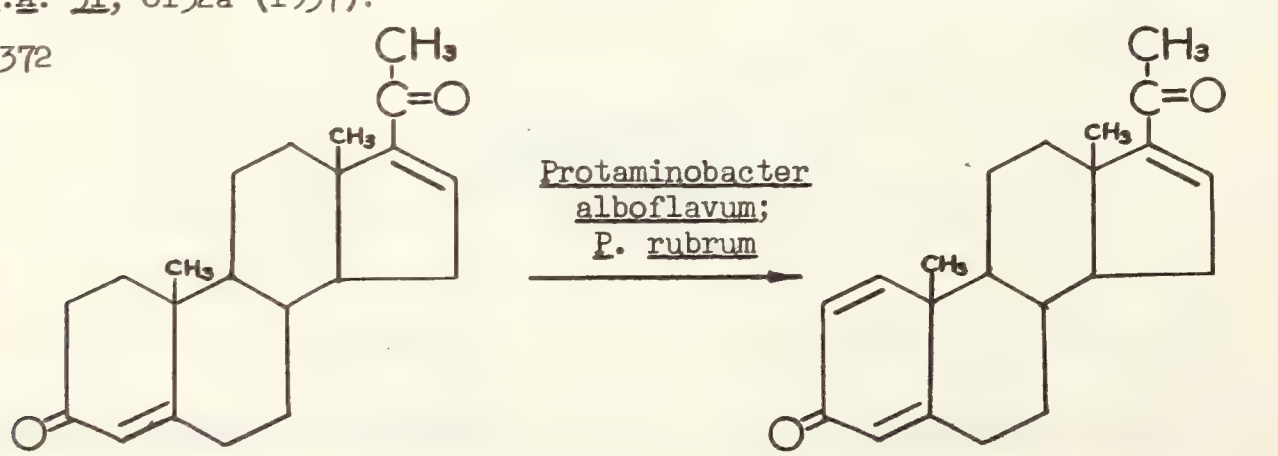


Δ^{11}-dehydroprogesterone

$\Delta^{1,4,11}$-pregnatriene-3,20-dione

Shull, U.S. 2,776,927 (Jan. 8, 1957).
C.A. 51, 8152a (1957).

Rx. 372



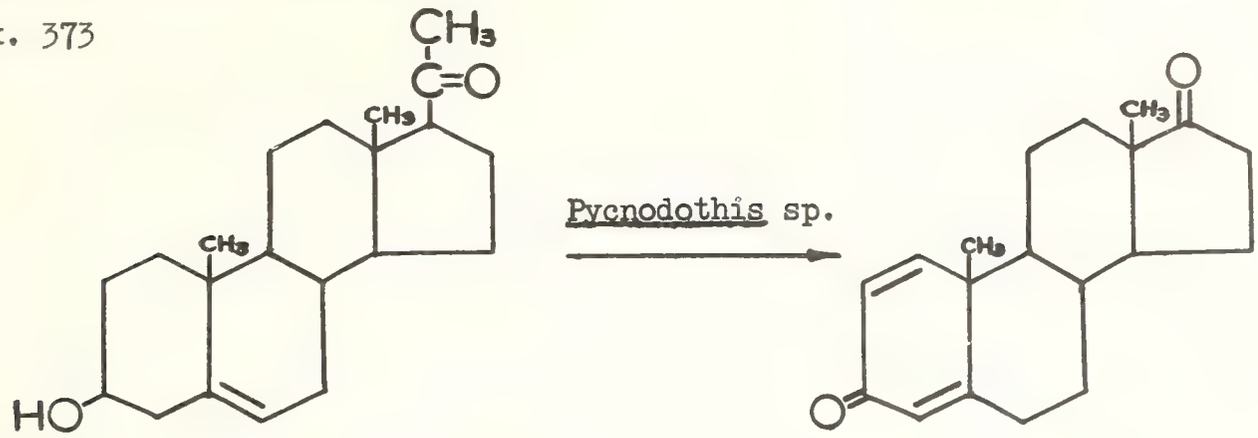
Δ^{16}-dehydroprogesterone

$\Delta^{1,4,16}$-pregnatriene-3,20-dione

Kita and Shull, in Shull, Trans. N. Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 373



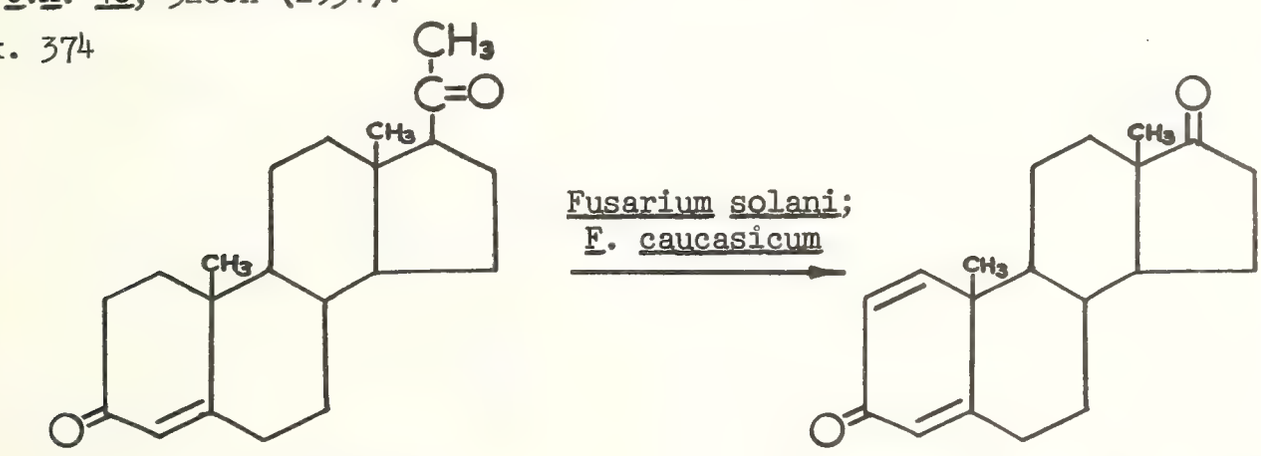
Δ^5-pregnene-3β-ol-20-one

$\Delta^{1,4}$-androstadiene-3,17-dione

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 374



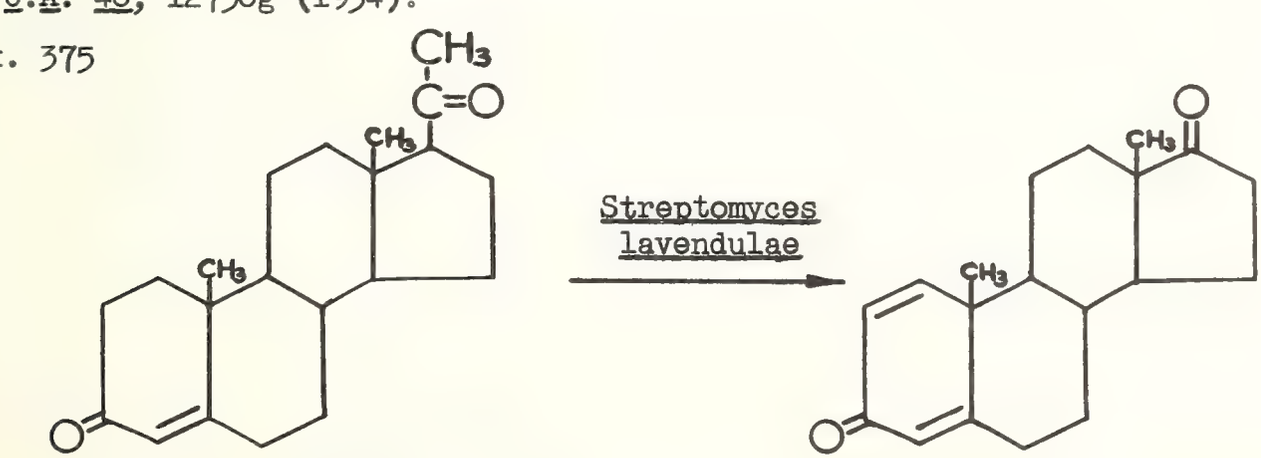
progesterone

$\Delta^{1,4}$-androstadiene-3,17-dione

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 375



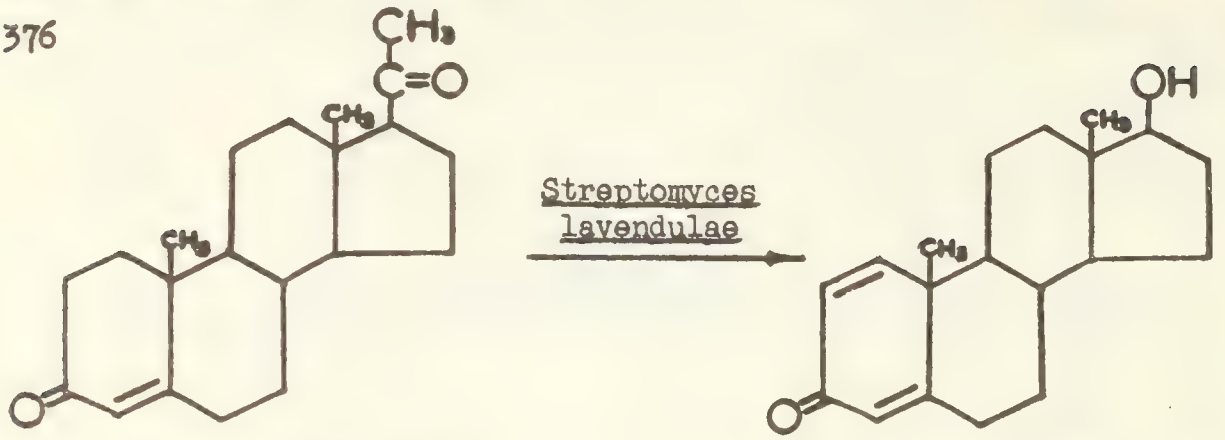
progesterone

$\Delta^{1,4}$-androstadiene-3,17-dione
(7%)

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 376



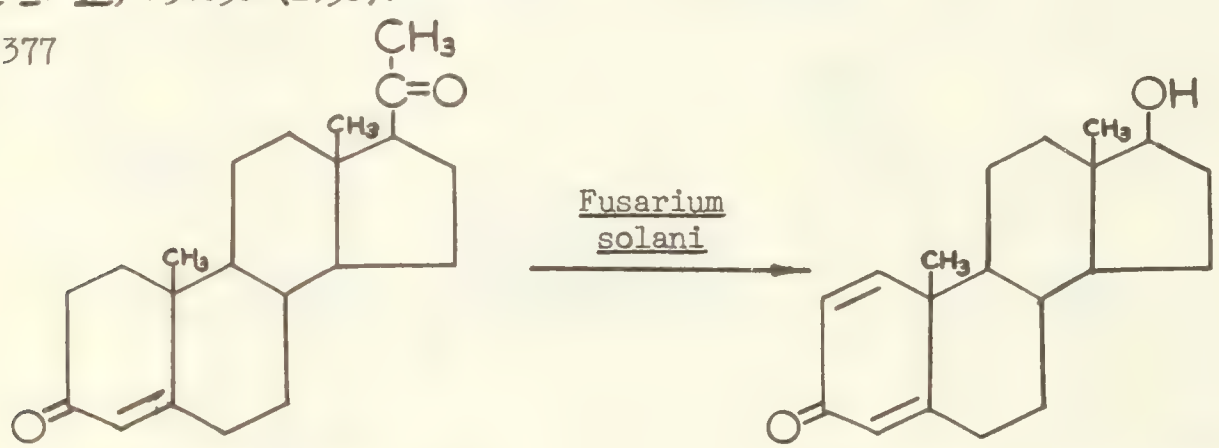
progesterone

Δ^1-dehydrotestosterone (12%)

Nishikawa et al., Pharm. Bull. (Japan) 3, 322-3 (1955).

C.A. 50, 13165e (1956).

Rx. 377



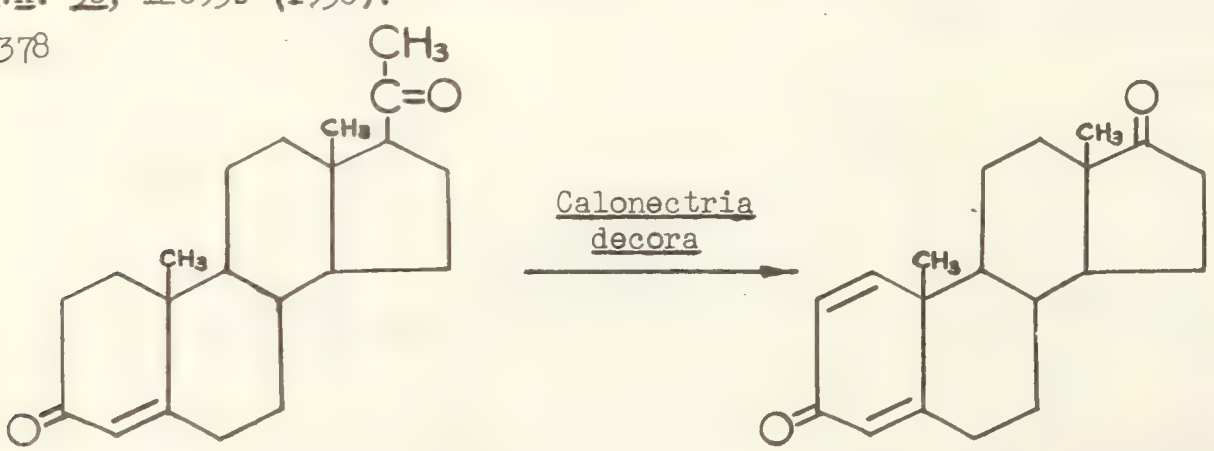
progesterone

$\Delta^{1,4}$-androstadiene-17β-ol-3-one

Vischer et al., Helv. Chim. Acta 38, 835-40 (1955).

C.A. 50, 12093b (1956).

Rx. 378



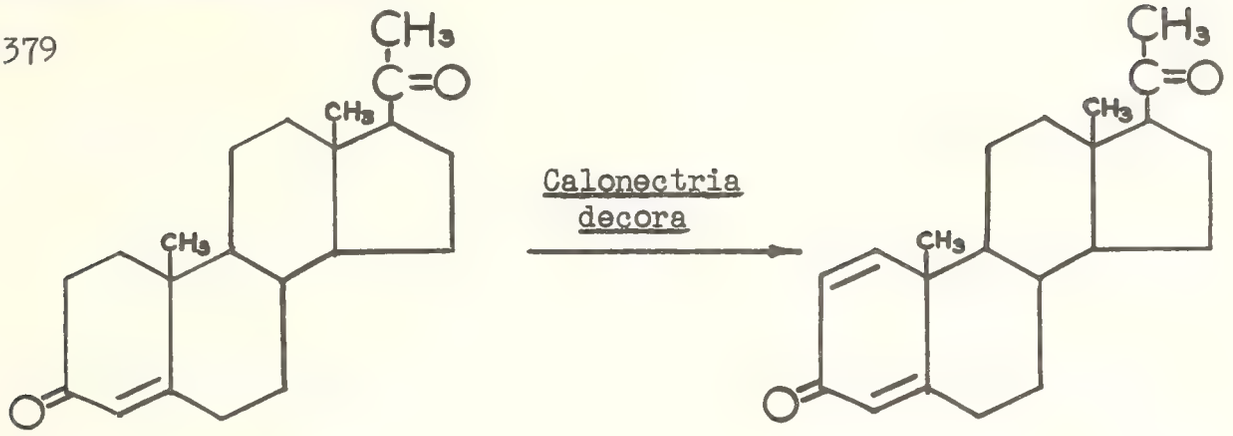
progesterone

$\Delta^{1,4}$-androstadiene-3,17-dione

Vischer et al., Helv. Chim. Acta 38, 835-40 (1955).

C.A. 50, 12093b (1956).

Rx. 379



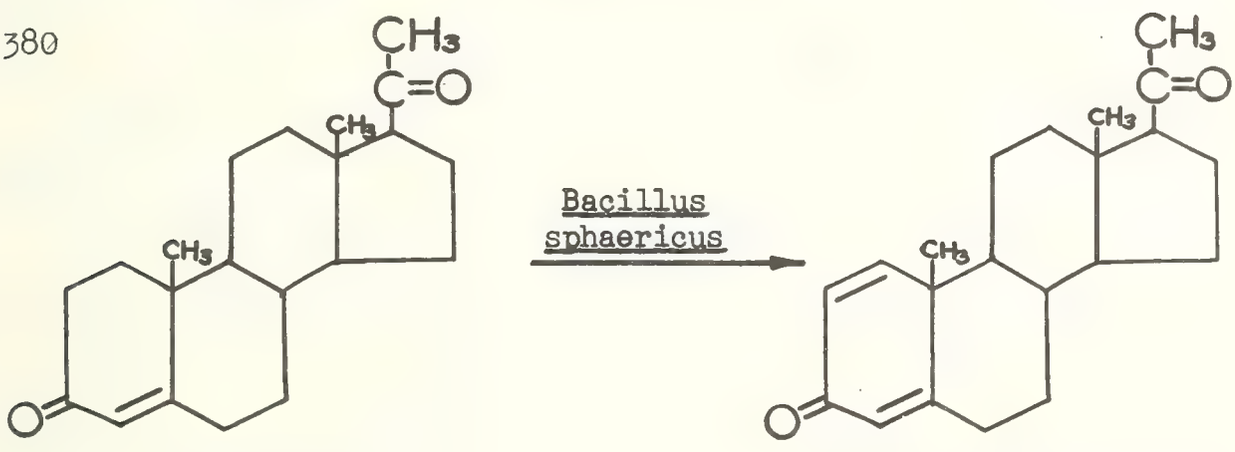
progesterone

Δ^1-dehydroprogesterone

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 380



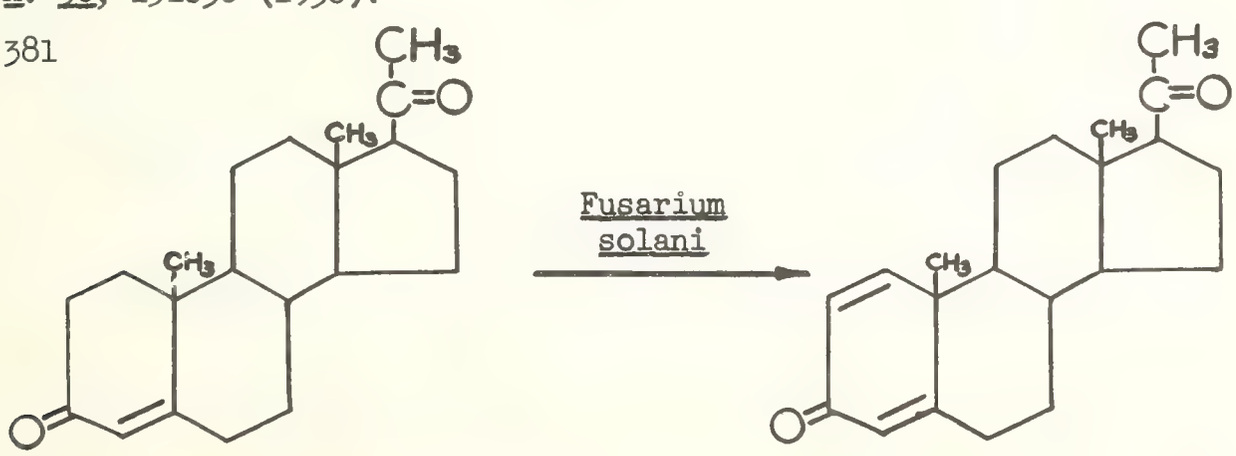
progesterone

Δ^1-dehydroprogesterone

Nishikawa et al., Pharm. Bull. (Japan) 3, 322-3 (1955).

C.A. 50, 13165e (1956).

Rx. 381



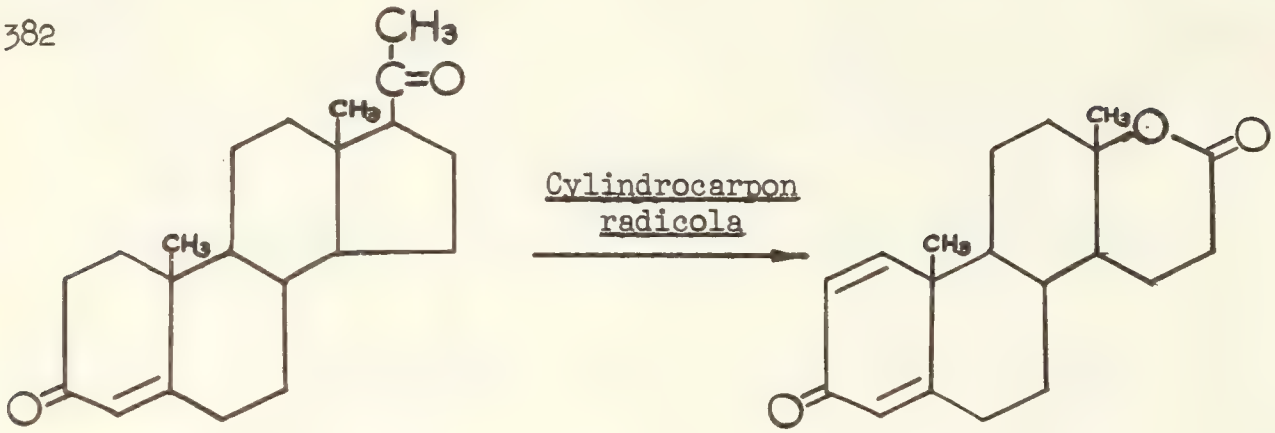
progesterone

Δ^1-dehydroprogesterone

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 382



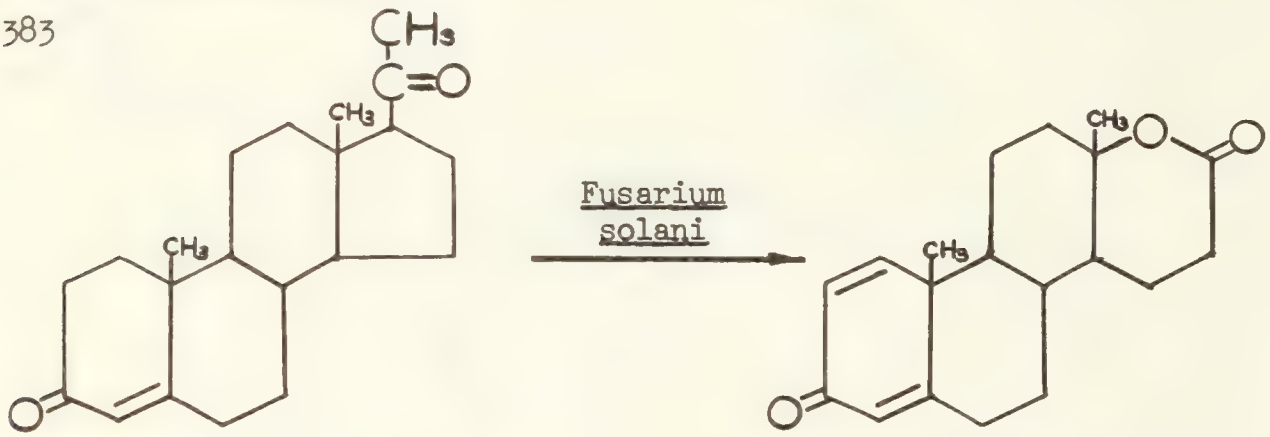
progesterone

Δ^1-dehydrotestololactone (50%)

Nishikawa et al., Pharm. Bull. (Japan) 3, 322-3 (1955).

C.A. 50, 13165e (1956).

Rx. 383



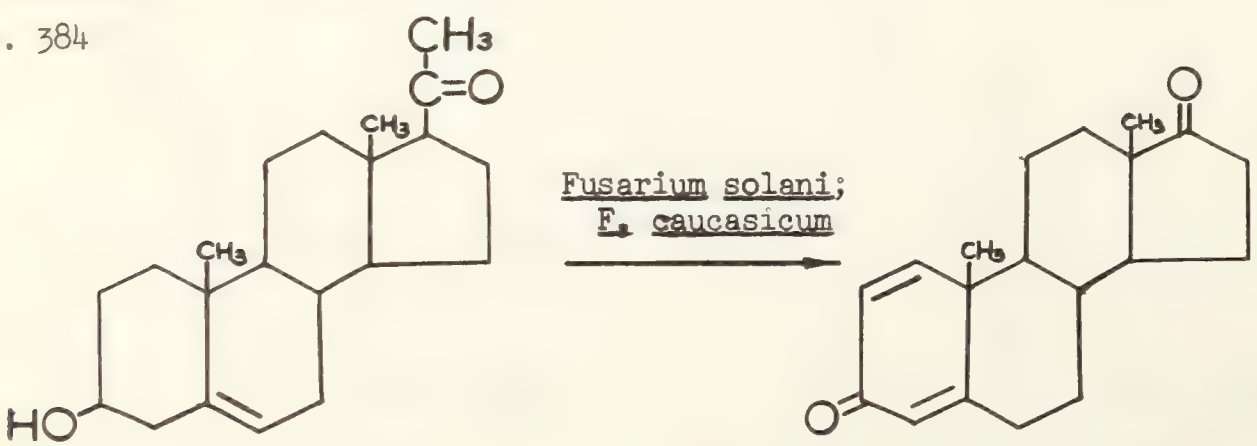
progesterone

Δ^1-dehydrotestololactone

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 384



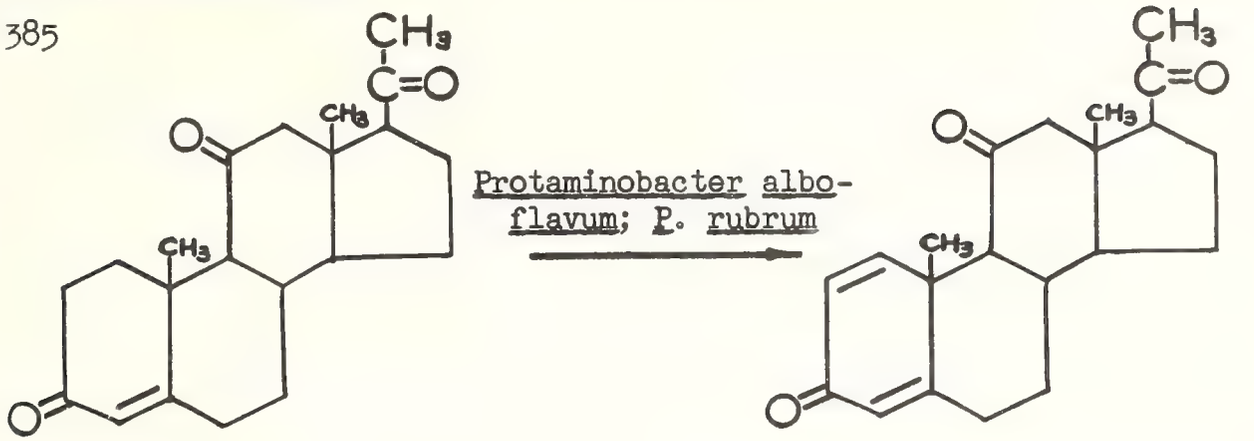
Δ^5-pregnene-3β-ol-20-one

$\Delta^{1,4}$-androstadiene-3,17-dione

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 385



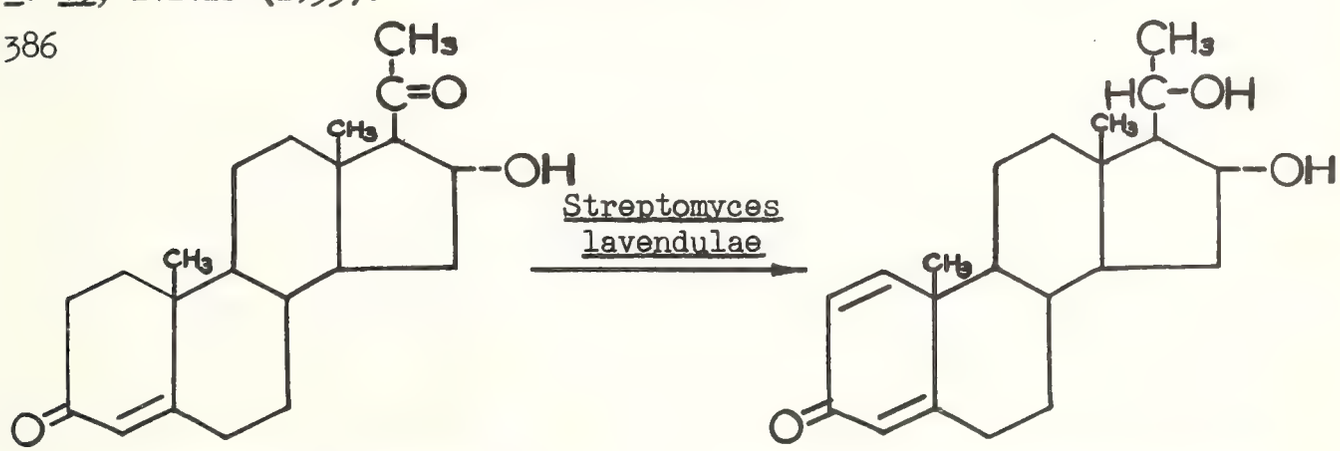
11-ketoprogesterone

$\Delta^{1,4}$-pregnadiene-3,11,20-trione

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 386



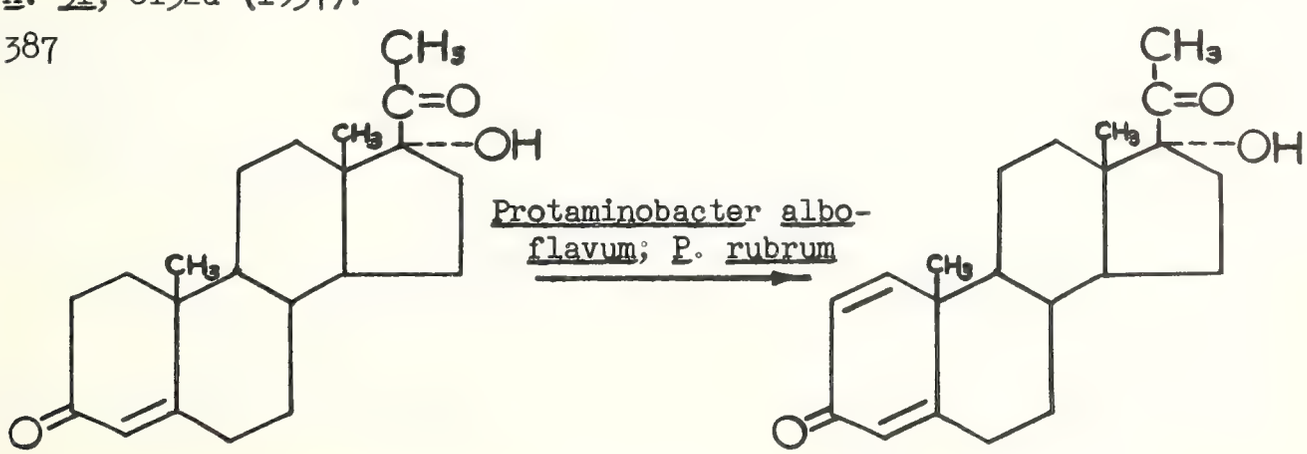
16α-hydroxyprogesterone

$\Delta^{1,4}$-pregnadiene-16α,20β-diol-3-one

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 387



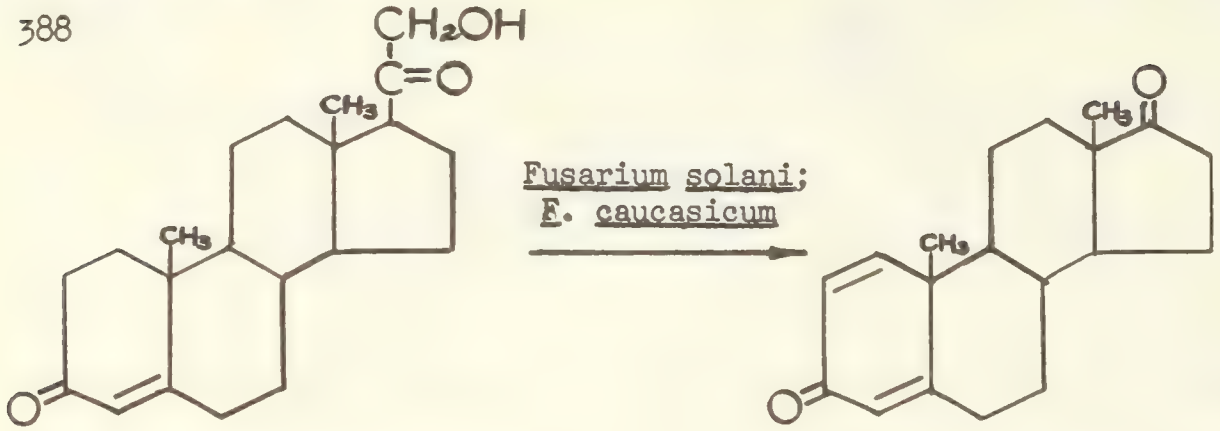
17α-hydroxyprogesterone

$\Delta^{1,4}$-pregnadiene-17α-ol-3,20-dione

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 388



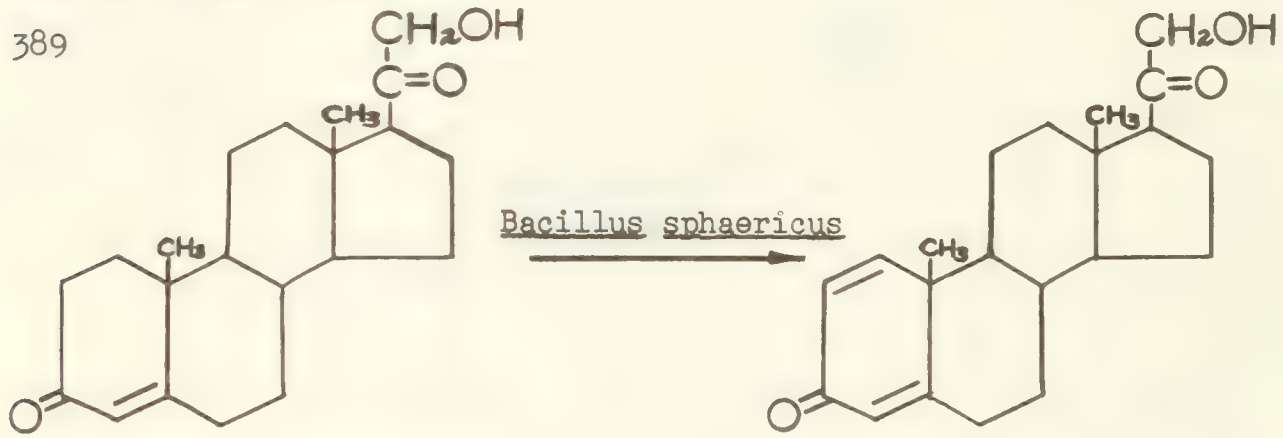
11-desoxycorticosterone (cortexone)

$\Delta^{1,4}$-androstadiene-3,17-dione

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 389



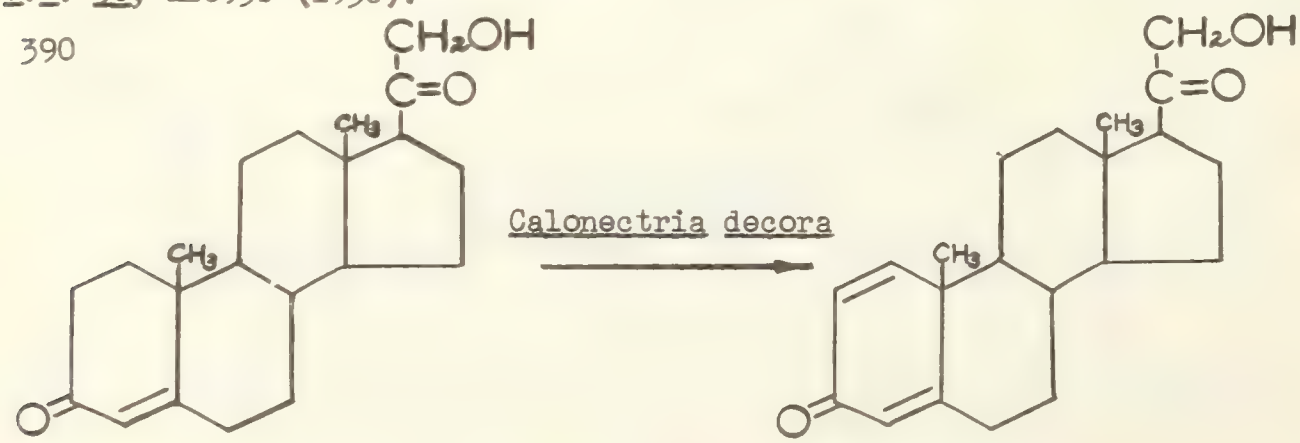
11-desoxycorticosterone

Δ^{1}-dehydro-11-desoxycorticosterone

Vischer et al., Helv. Chim. Acta 38, 835-40 (1955).

C.A. 50, 12093b (1956).

Rx. 390



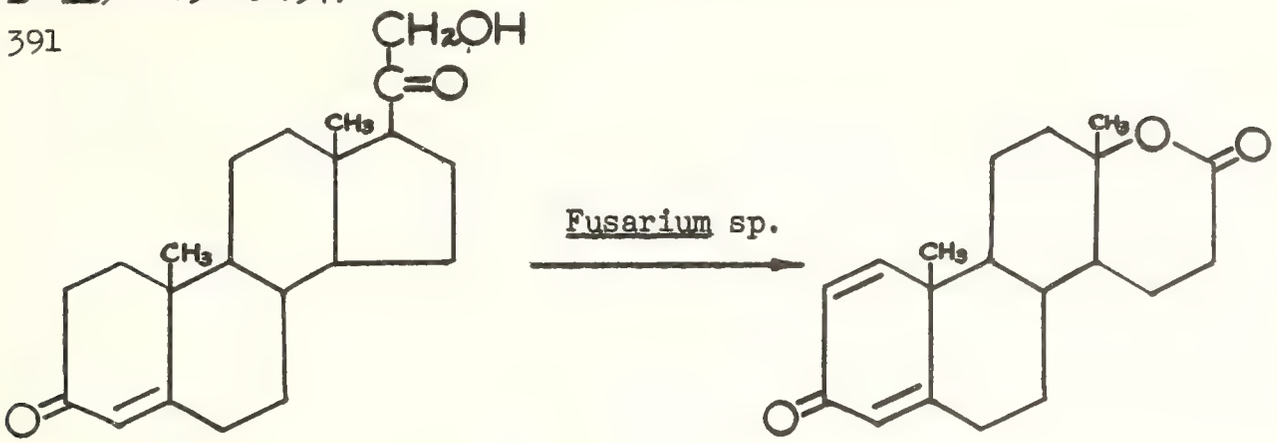
11-desoxycorticosterone

$\Delta^{1,4}$-pregnadiene-21-ol-3,20-dione

Shull and Bloom, in Shull, Trans. N. Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 391



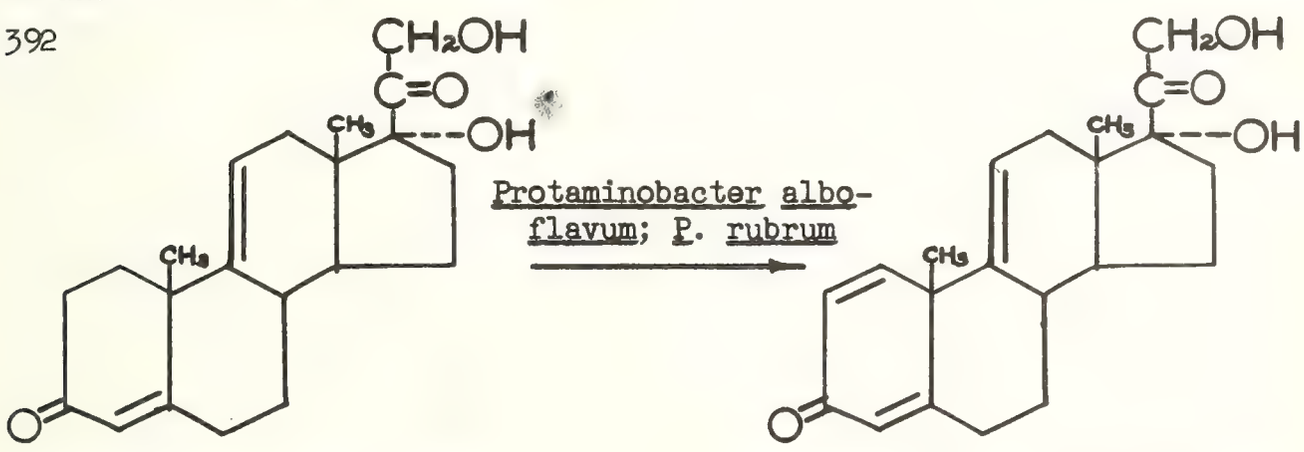
11-desoxycorticosterone

Δ^1-dehydrotestololactone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 392



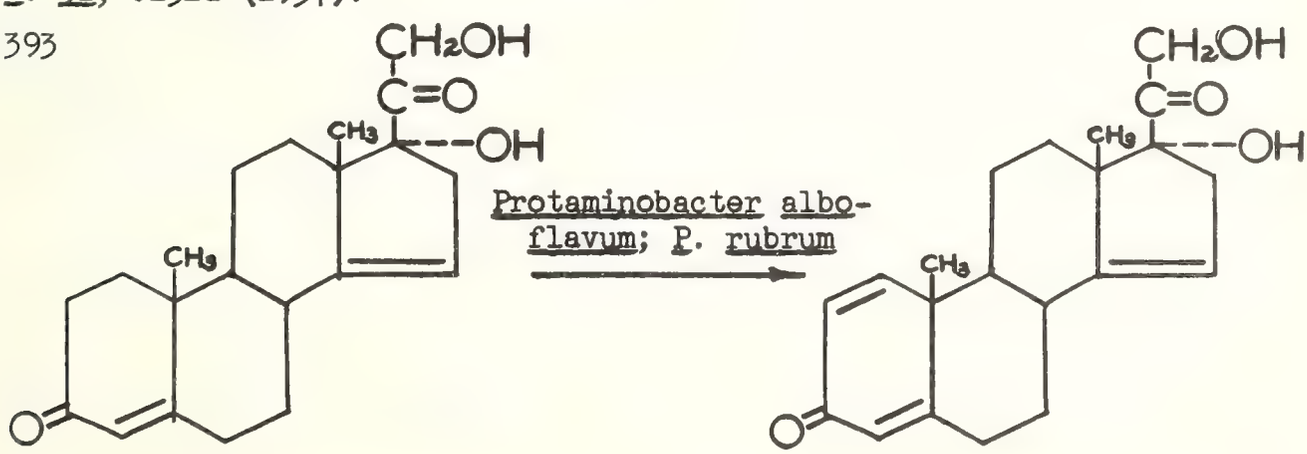
$\Delta^{4,9(11)}$-pregnadiene-17α, 21-diol-3,20-dione

$\Delta^{1,4,9(11)}$-pregnatriene-17α, 21-diol-3,20-dione

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 393



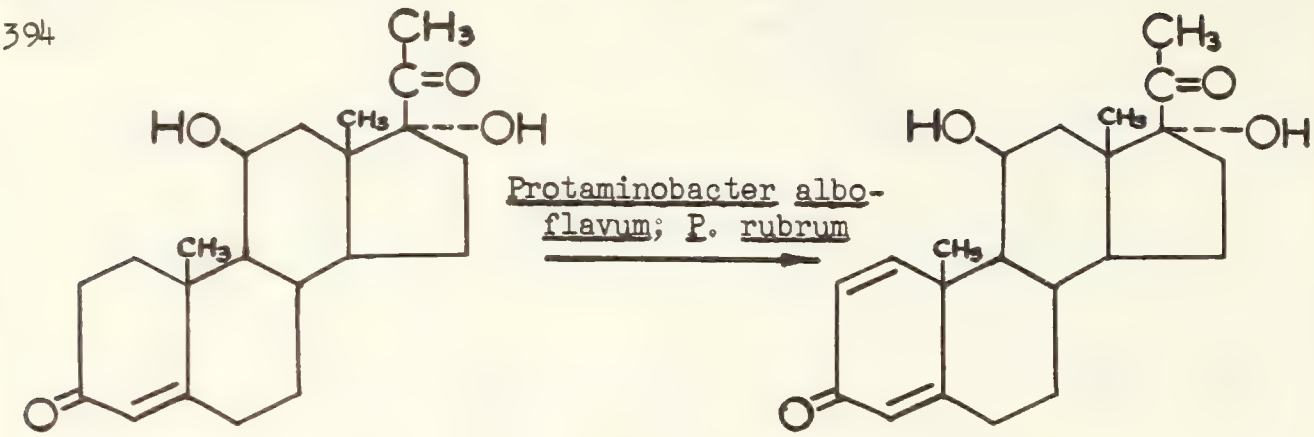
$\Delta^{4,14}$-pregnadiene-17α, 21-diol-3,20-dione

$\Delta^{1,4,14}$-pregnatriene-17α, 21-diol-3,20-dione

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 394



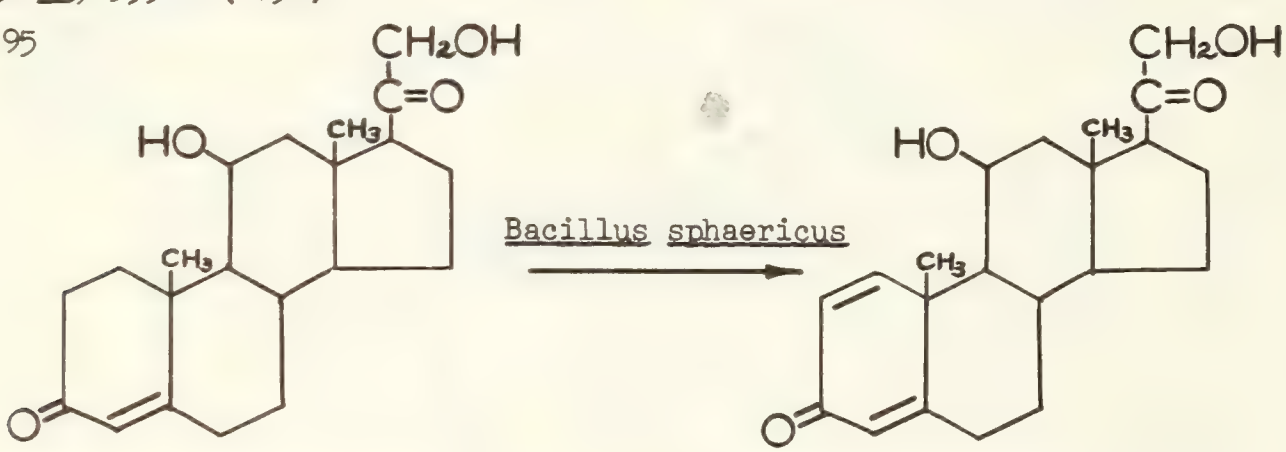
11β,17α-dihydroxyprogesterone

$\Delta^{1,4}$-pregnadiene-11β,17α-diol-3,20-dione

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 395



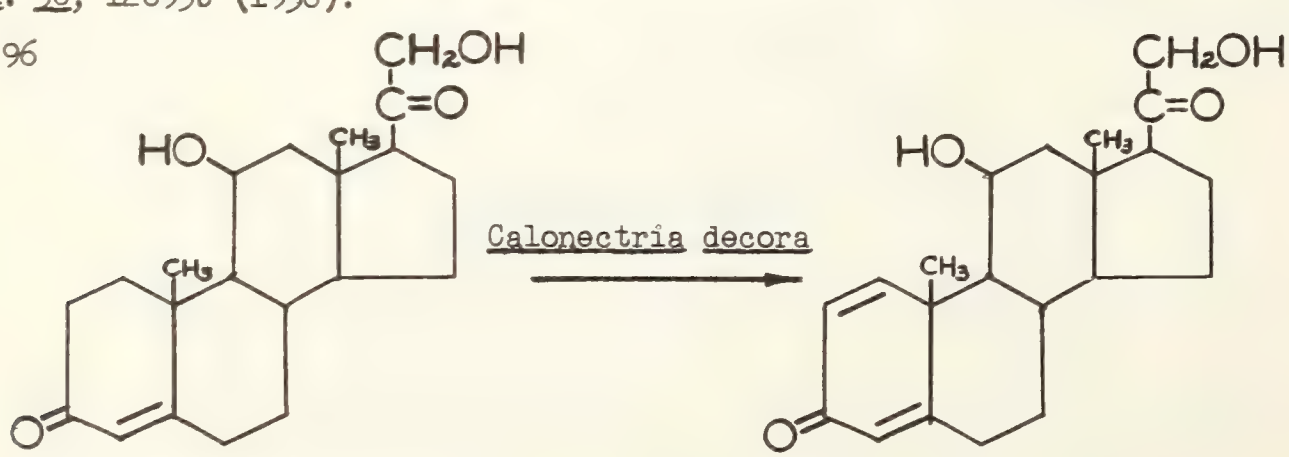
corticosterone

Δ^{1}-dehydrocorticosterone

Vischer et al., Helv. Chim. Acta 38, 835-40 (1955).

C.A. 50, 12093b (1956).

Rx. 396



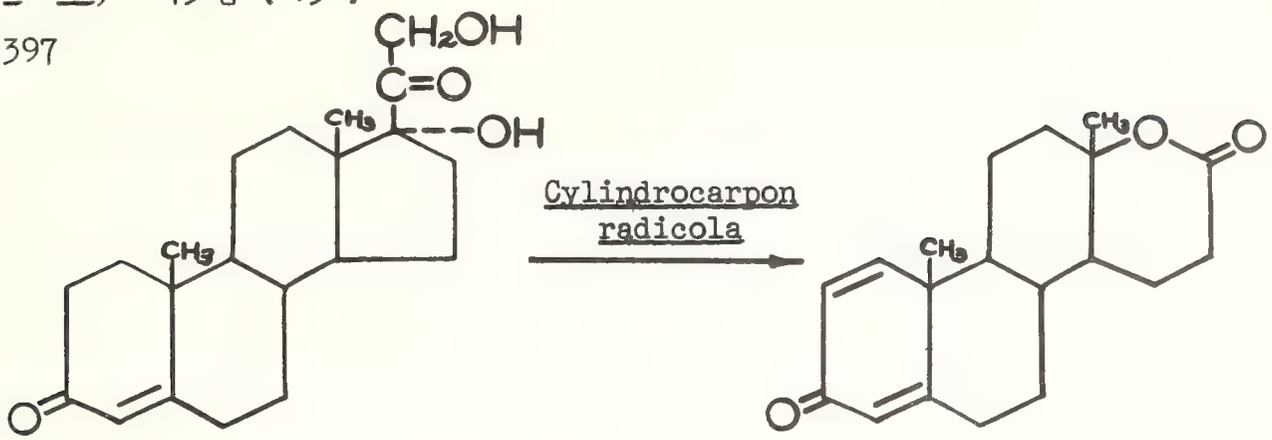
corticosterone

Δ^{1}-dehydrocorticosterone

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 397



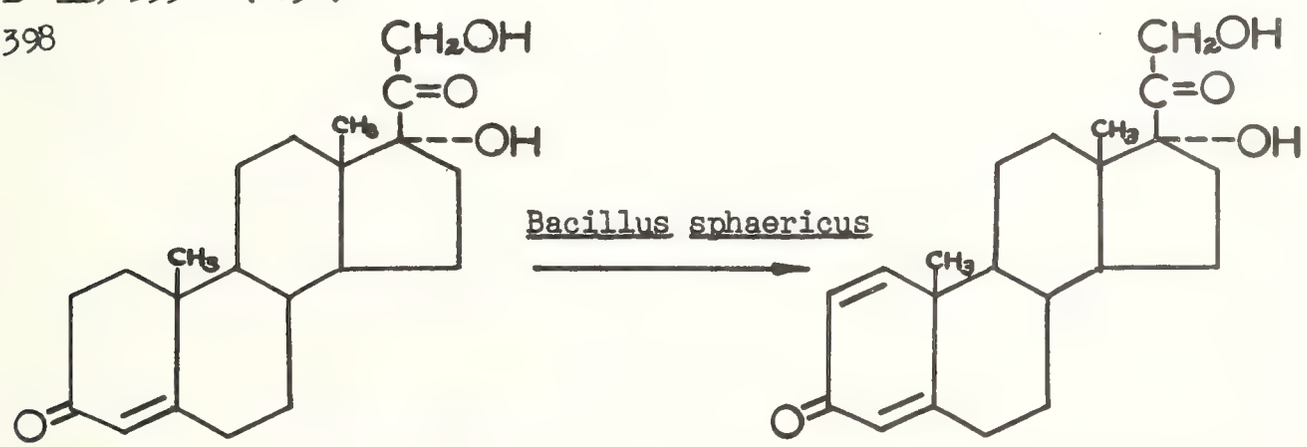
17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd. S)

Δ^1-dehydrotestololactone (50%)

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 398



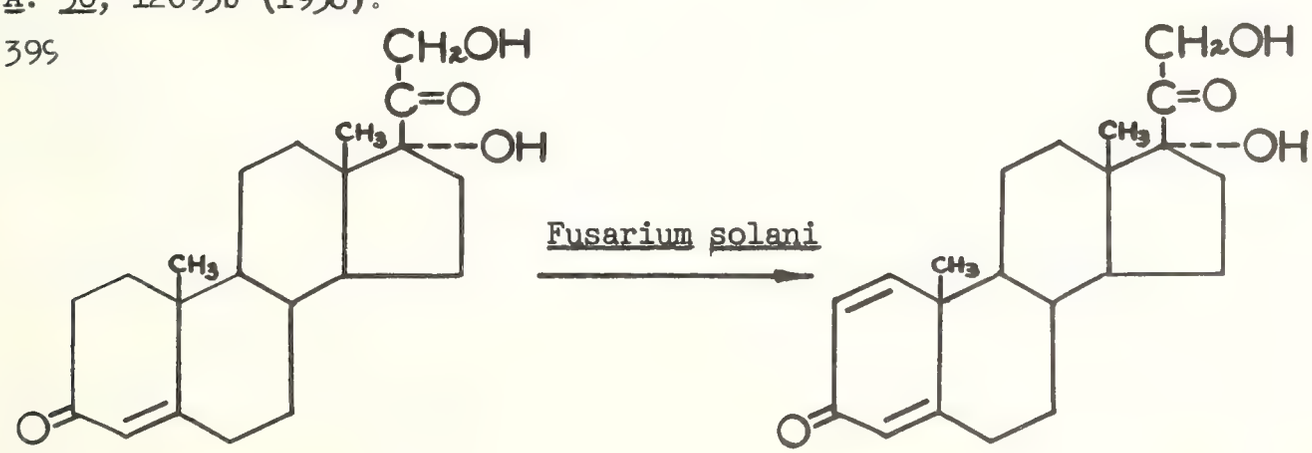
17α-hydroxy-11-desoxycorticosterone

Δ^1-dehydro-17α-hydroxycortexone

Vischer et al., Helv. Chim. Acta 38, 835-40 (1955).

C.A. 50, 12093b (1956).

Rx. 399



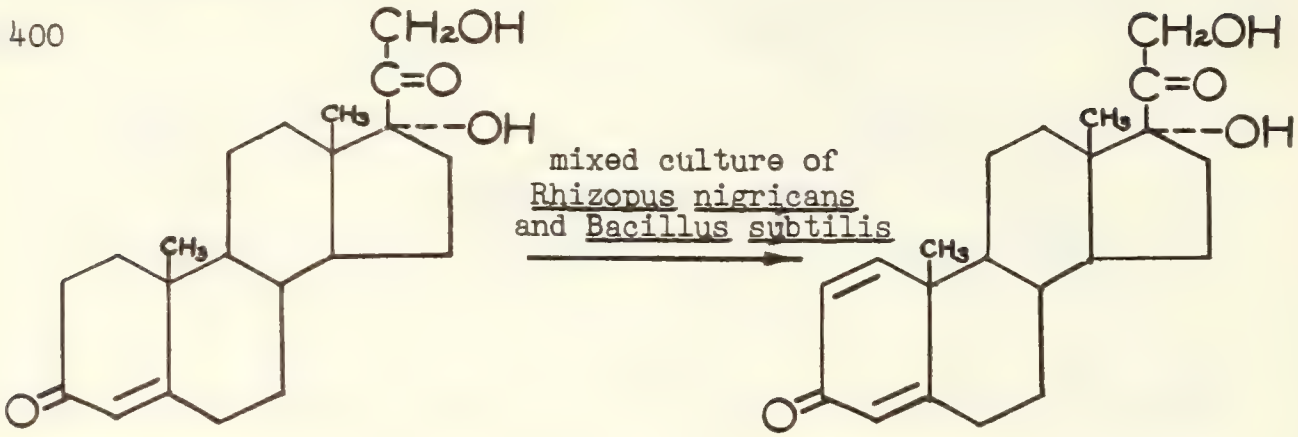
17α-hydroxy-11-desoxycorticosterone

Δ^1-dehydro-17α-hydroxycortexone

Lindner et al., Naturwissenschaften 43, 39 (1956).

C.A. 51, 14008c (1957).

Rx. 400



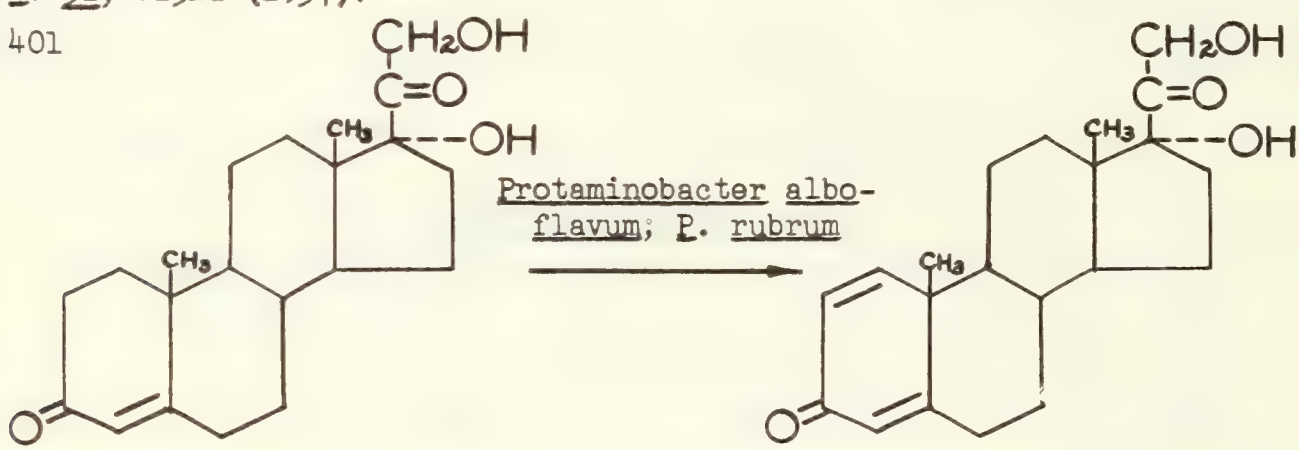
17α-hydroxy-11-desoxycorticosterone

Δ^1-dehydro-17α-hydroxy-cortexone (80%)

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 401



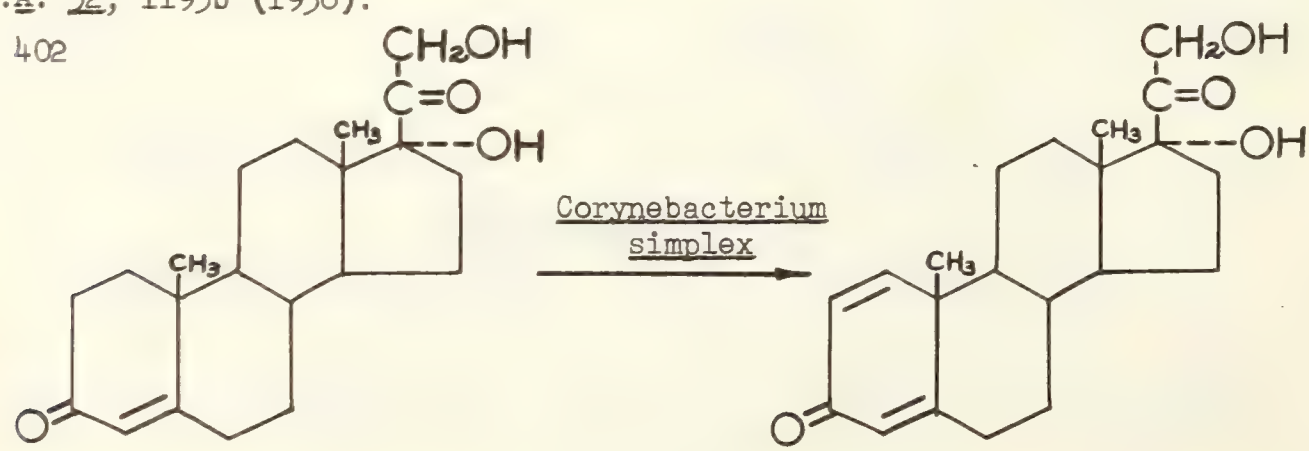
17α-hydroxy-11-desoxycorticosterone

$\Delta^{1,4}$-pregnadiene-17α,21-diol-3,20-dione

Sutter et al., J. Org. Chem. 22, 578-9 (1957).

C.A. 52, 1193b (1958).

Rx. 402



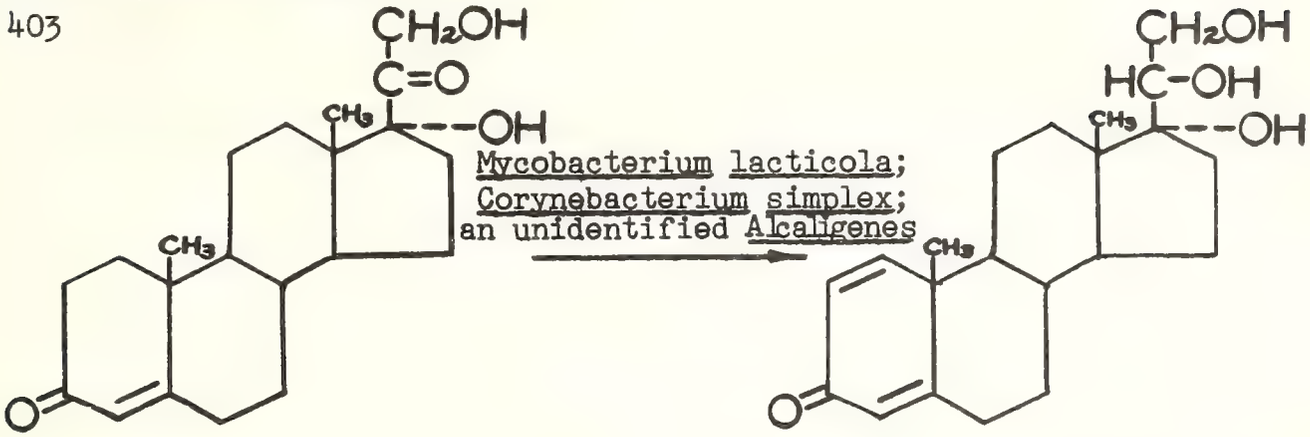
17α-hydroxy-11-desoxycorticosterone

$\Delta^{1,4}$-pregnadiene-17α,21-diol-3,20-dione

Sutter et al., J. Org. Chem. 22, 578-9 (1957).

C.A. 52, 1193b (1958).

Rx. 403



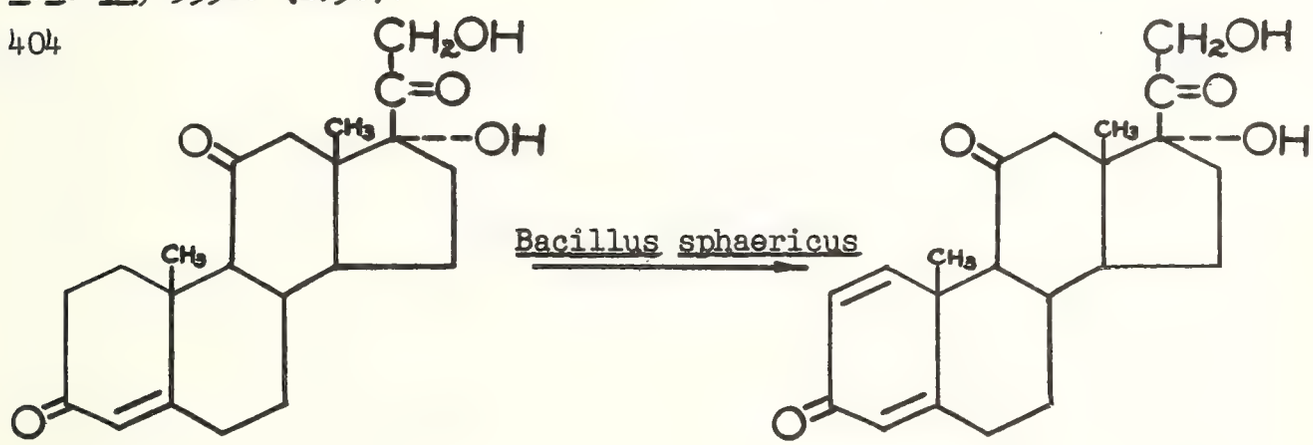
17α-hydroxy-11-desoxy-corticosterone

$\Delta^{1,4}$-pregnadiene-17α,20β,21-triol-3-one

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 404



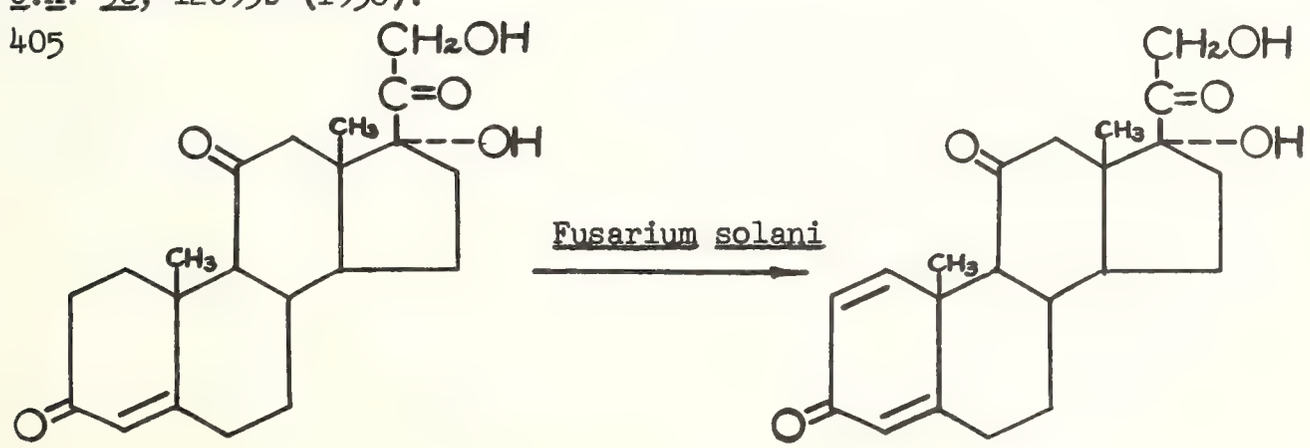
cortisone

Δ^{1}-dehydrocortisone (prednisone)

Vischer et al., Helv. Chim. Acta, 38, 835-40 (1955).

C.A. 50, 12093b (1956).

Rx. 405

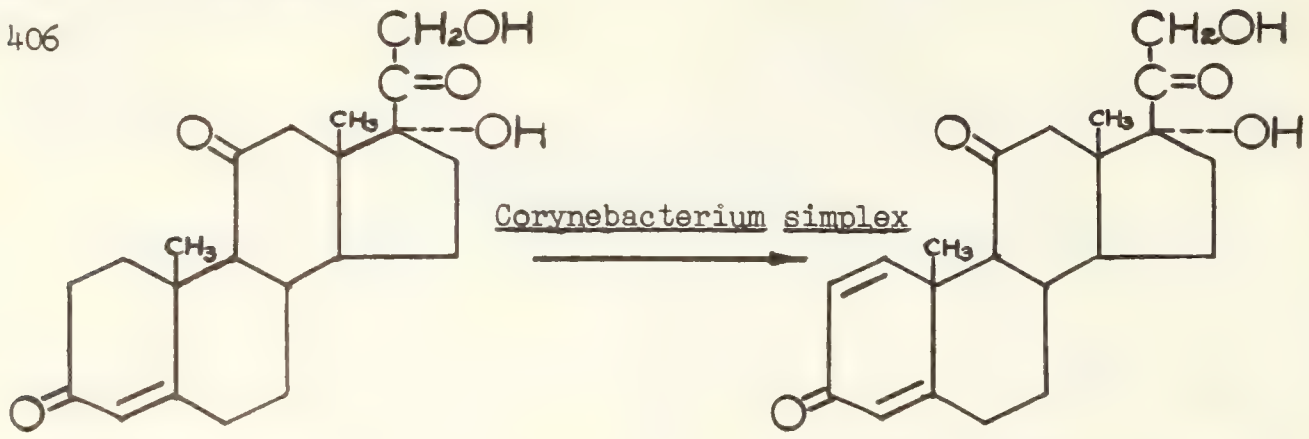


cortisone

Δ^{1}-dehydrocortisone

Schering Corp., Chem. Eng. News 33, 3670-1 (1955). See JACS 77, 4184 (1955). See C.A. 49, 15179i (1955).

Rx. 406



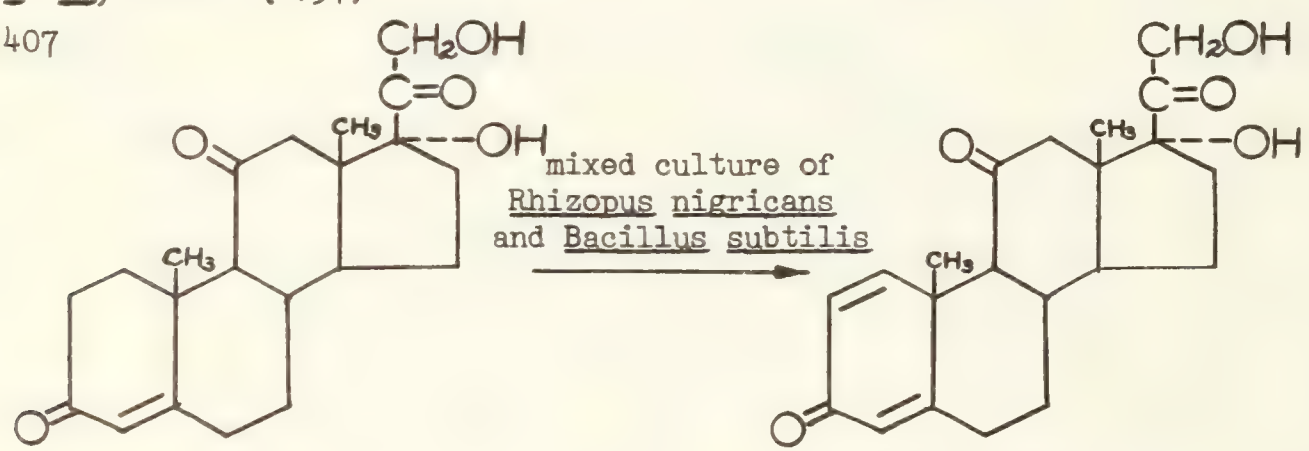
cortisone

Δ^1-dehydrocortisone (approx. 70%)

Lindner et al., Naturwissenschaften 43, 39 (1956).

C.A. 51, 14008c (1957).

Rx. 407



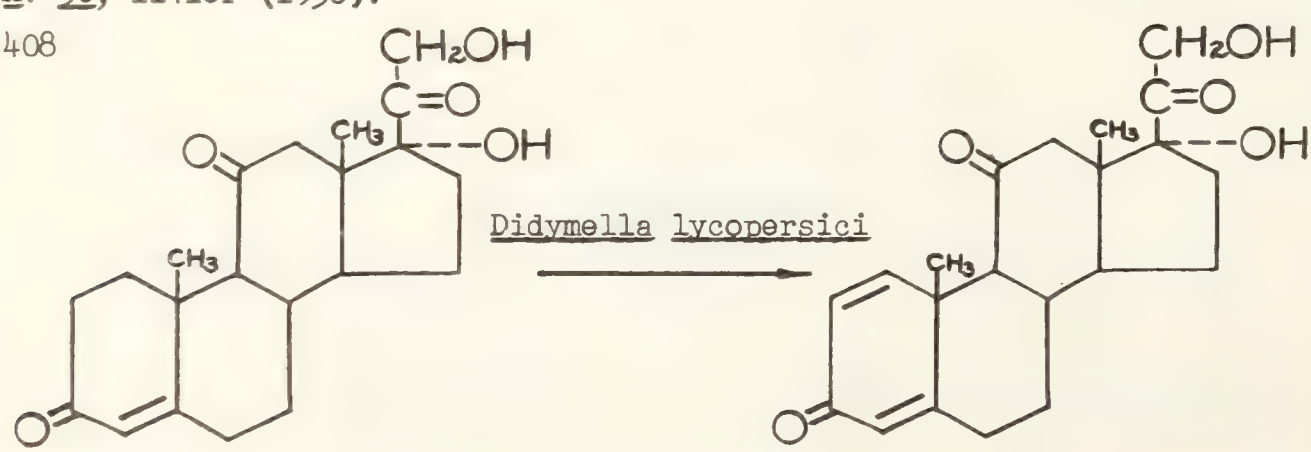
cortisone

Δ^1-dehydrocortisone

Vischer et al., Experientia 12, 50-2 (1956).

C.A. 50, 11418f (1956).

Rx. 408



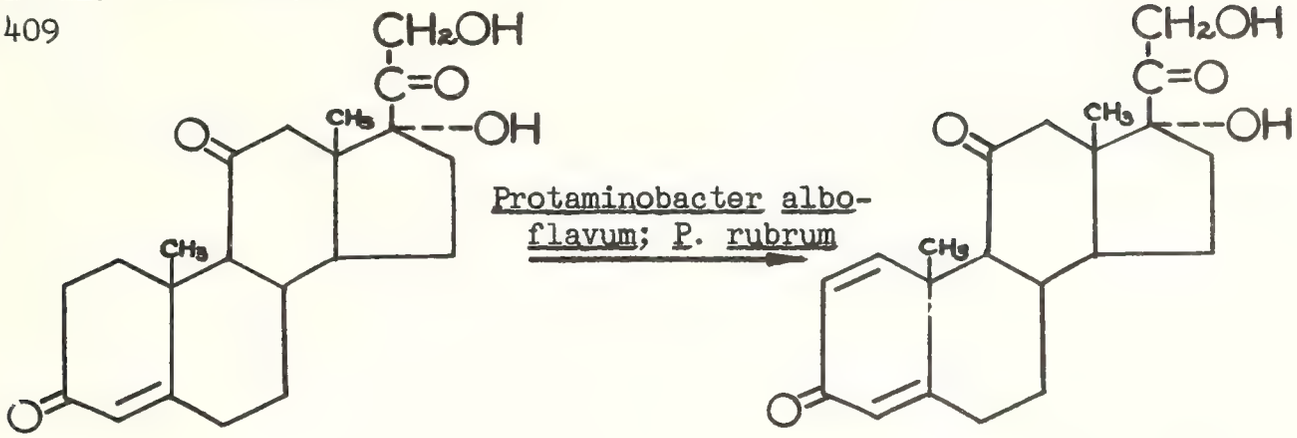
d,l-cortisone

d-Δ^1-dehydrocortisone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 409



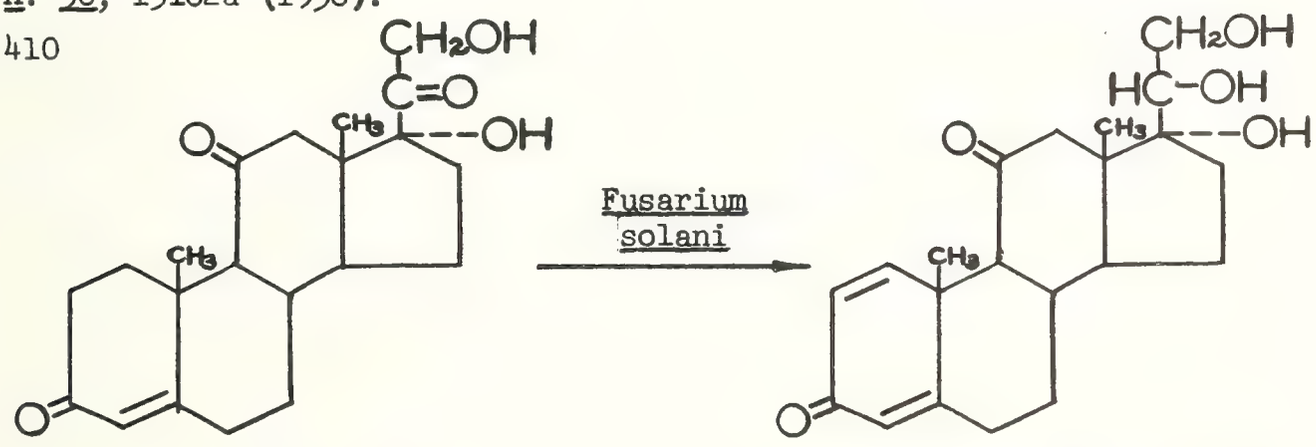
cortisone

Δ^1-dehydrocortisone

Szpilfogel et al., Rec. trav. chim. 75, 402-4 (1956).

C.A. 50, 13162a (1956).

Rx. 410



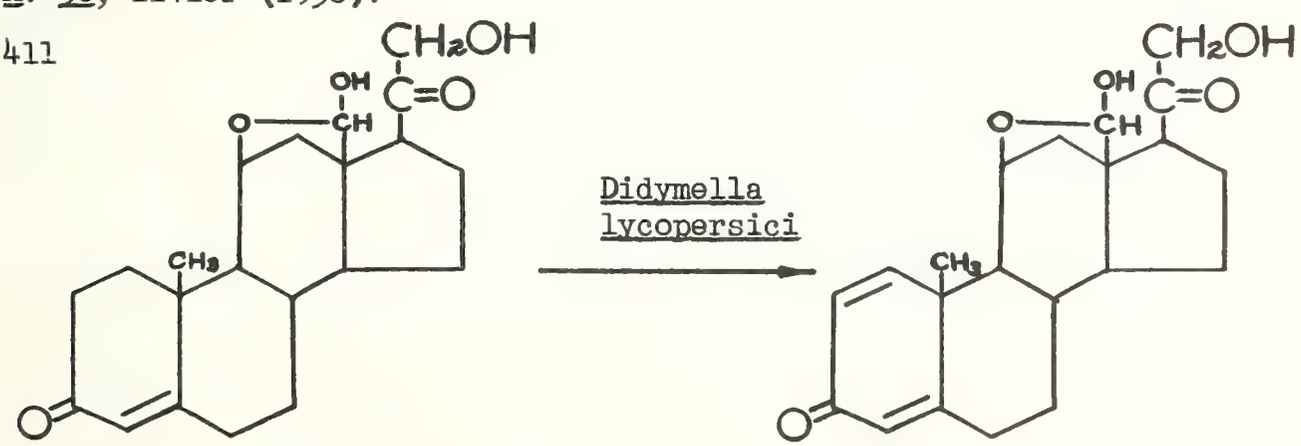
cortisone

$\Delta^{1,4}$-pregnadiene-17α,20β, 21-triol-3,11-dione

Vischer et al., Experientia 12, 50-2 (1956).

C.A. 50, 11418f (1956).

Rx. 411



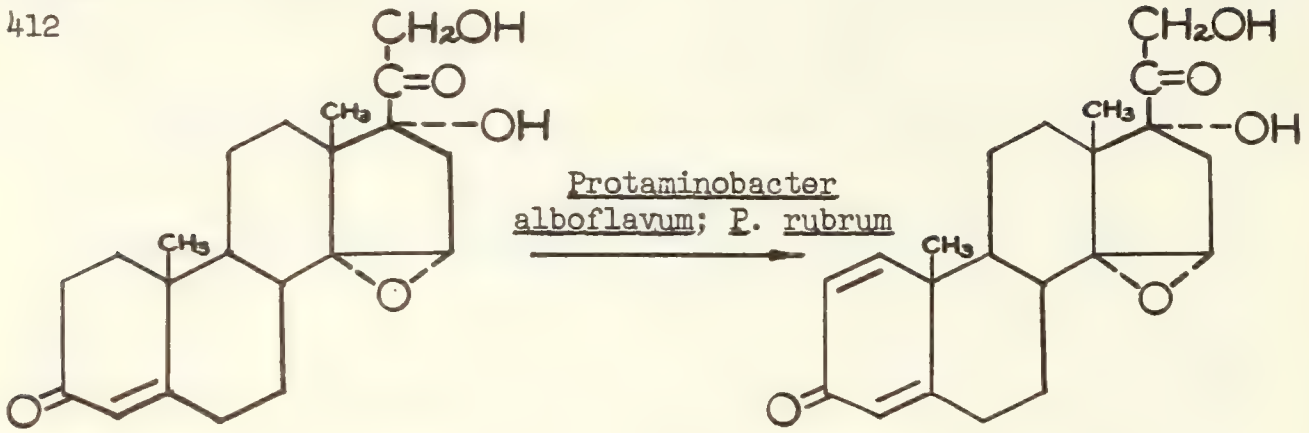
d,l-aldosterone

d-Δ^1-dehydroaldosterone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 412



Δ^4-pregnene-14α,15α-epoxido-17α,21-diol-3,20-dione

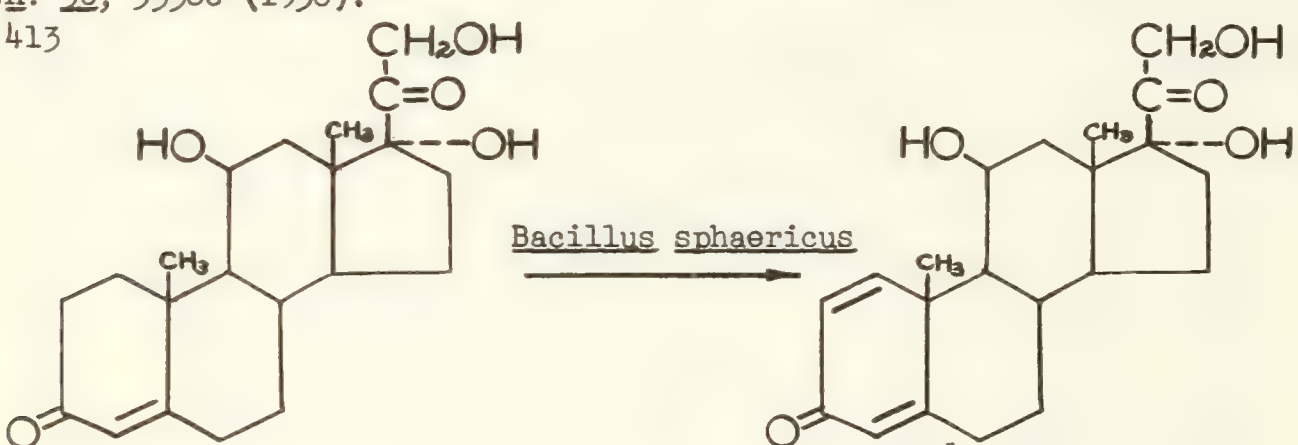
$\Delta^{1,4}$-pregnadiene-14α,15α-epoxido-17α,21-diol-3,20-dione

---

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 413



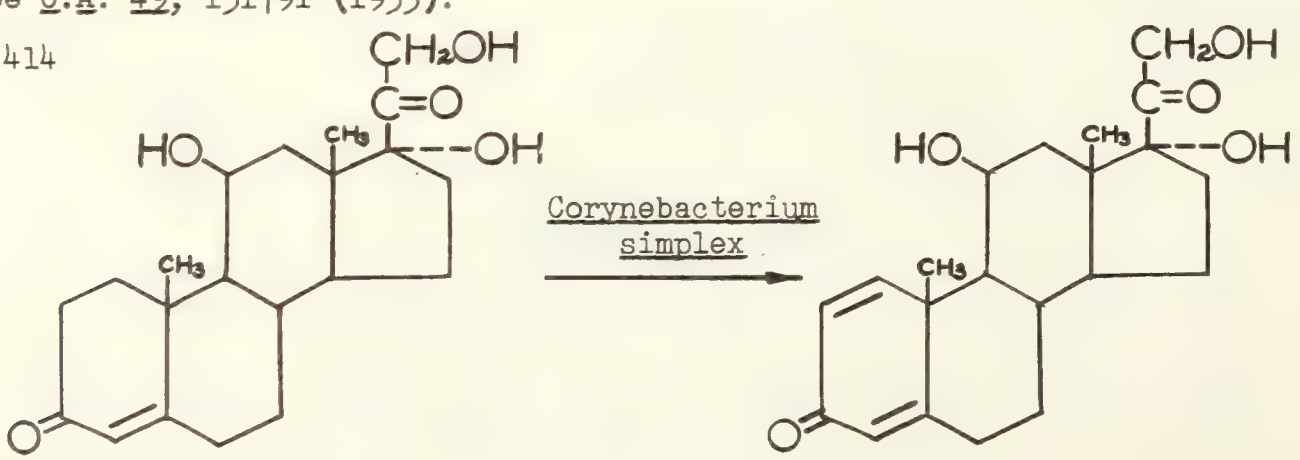
hydrocortisone (cortisol)

Δ^1-dehydro-17α-hydroxycorticosterone (prednisolone)

Schering Corp., Chem. Eng. News 33, 3670-1 (1955). See JACS 77, 4184 (1955).

See C.A. 49, 15179i (1955).

Rx. 414



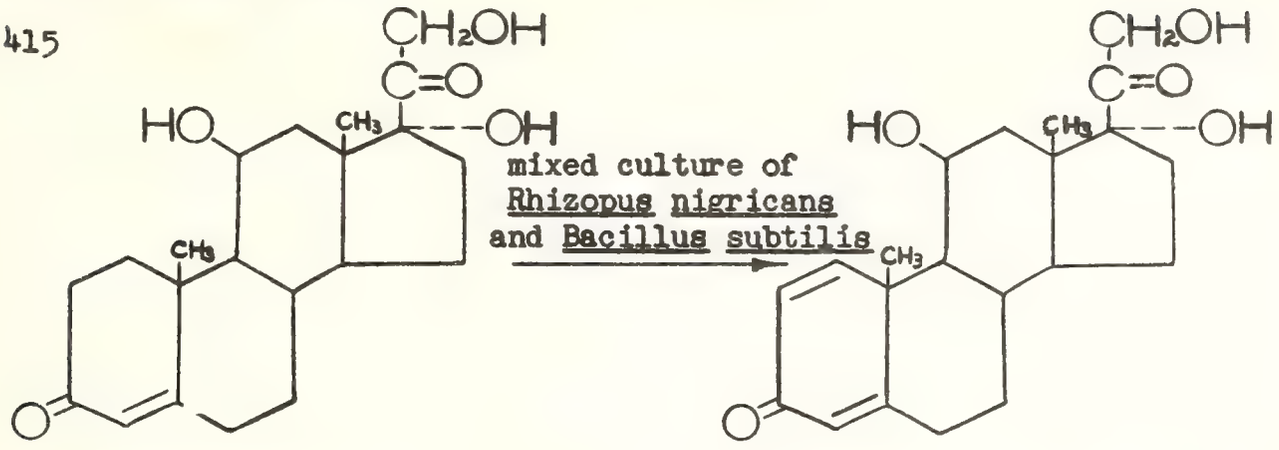
hydrocortisone

Δ^1-dehydro-17α-hydroxy-corticosterone

Lindner et al., Naturwissenschaften 43, 39 (1956).

C.A. 51, 14008c (1957).

Rx. 415



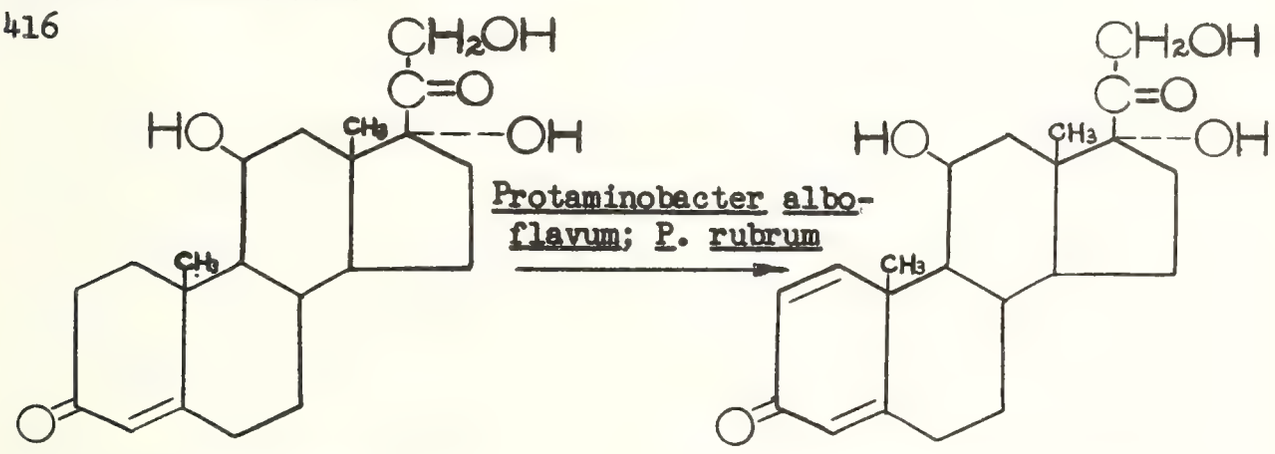
hydrocortisone

Δ^1-dehydro-17α-hydroxy-corticosterone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 416



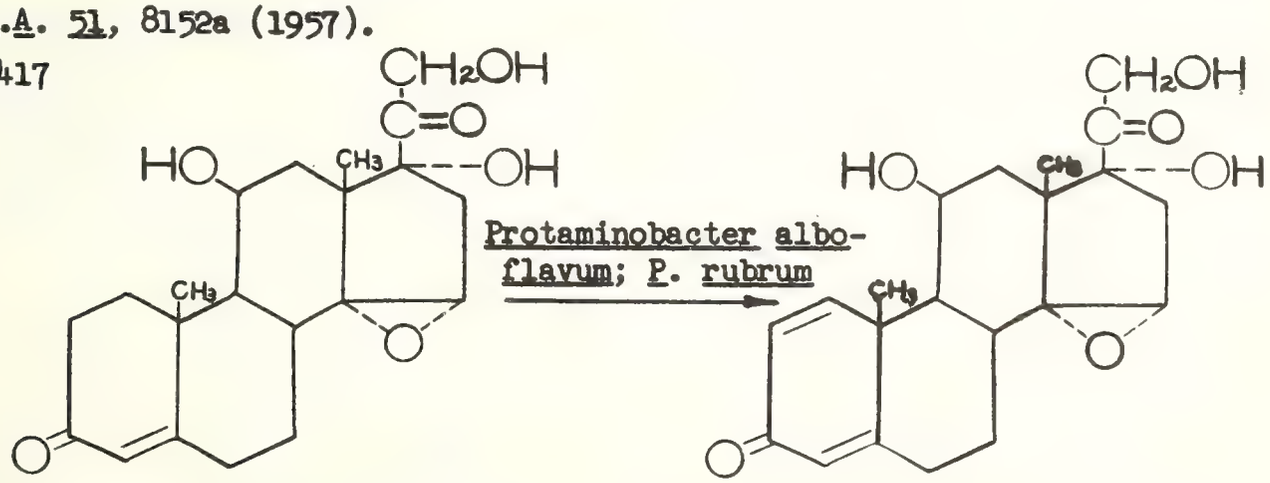
hydrocortisone

Δ^1-dehydro-17α-hydroxy-corticosterone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 417



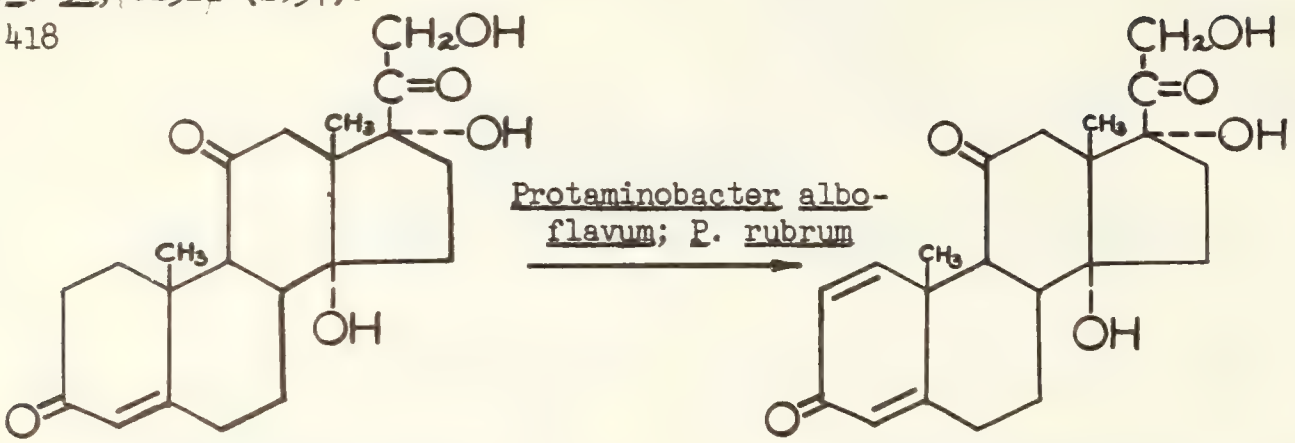
Δ^4-pregnene-14α,15α-epoxido-11β,17α,21-triol-3,20-dione

$\Delta^{1,4}$-pregnadiene-14α,15α-epoxido-11β,17α,21-triol-3,20-dione

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 418



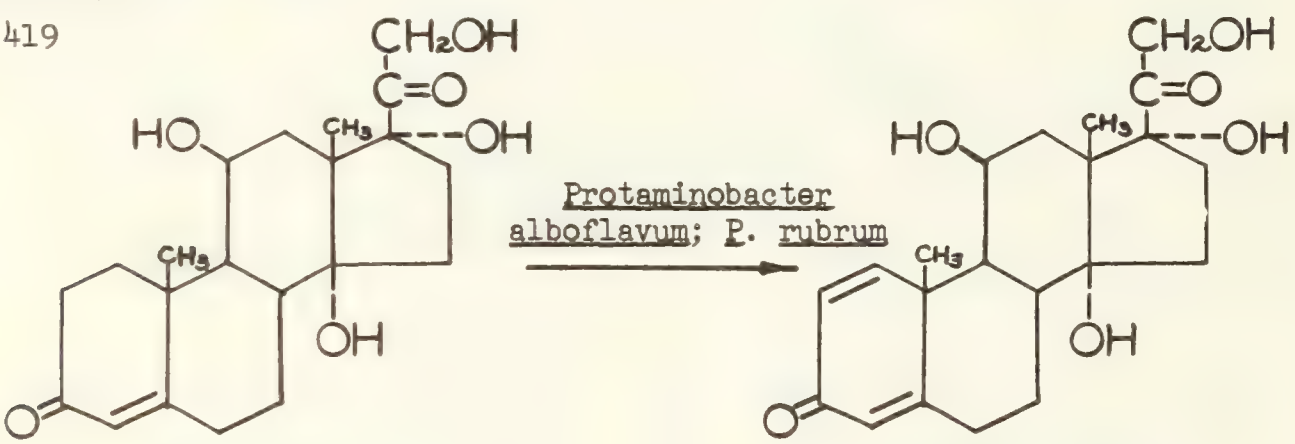
14α-hydroxycortisone

$\Delta^{1,4}$-pregnadiene-14α,17α,21-triol-3,11,20-trione

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 419



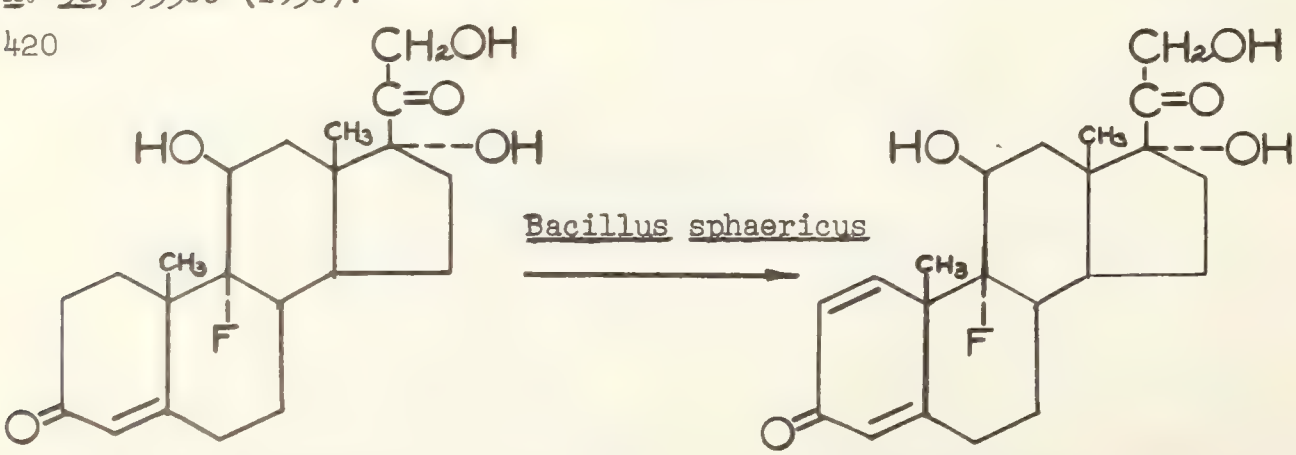
14α-hydroxyhydrocortisone

Δ^{1}-dehydro-14α-hydroxyhydrocortisone

Stoudt et al., Arch. Biochem. Biophys. 59, 304-5 (1955).

C.A. 50, 3558e (1956).

Rx. 420



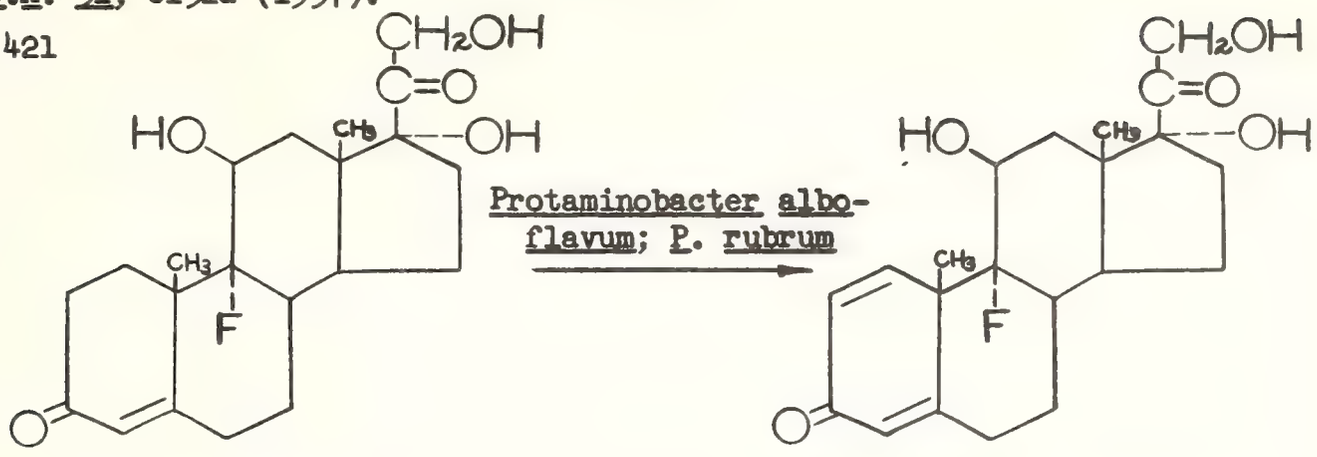
9α-fluorohydrocortisone

Δ^{1}-dehydro-9α-fluorohydrocortisone

Shull, U.S. 2,776,927 (Jan. 8, 1957).

C.A. 51, 8152a (1957).

Rx. 421



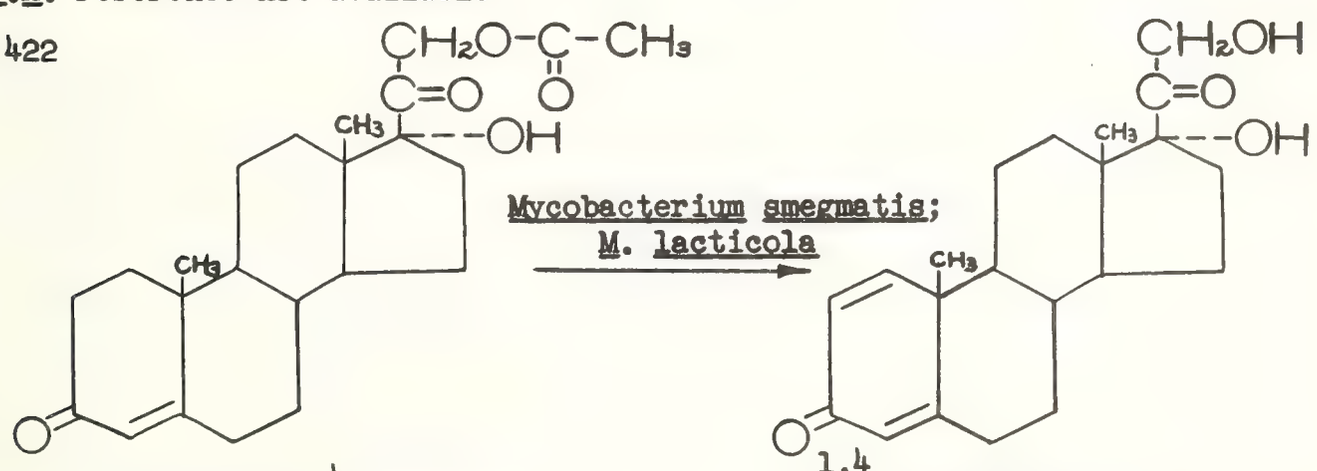
9α-fluorohydrocortisone

Δ^1-dehydro-9α-fluorohydrocortisone

Shull and Kita, Belg. 538,327 (May 21, 1955).

C.A. reference not available

Rx. 422



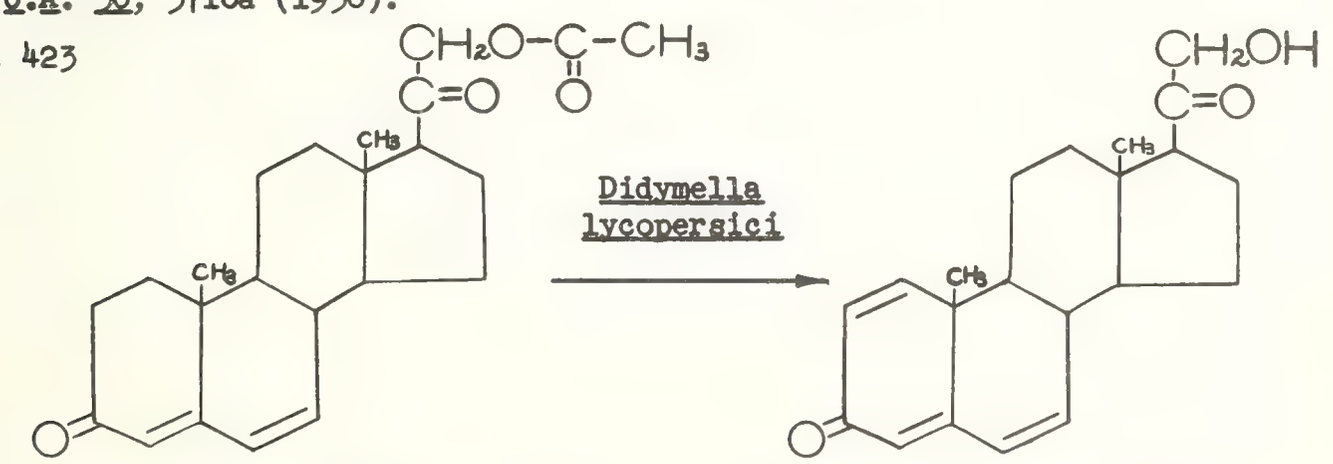
21-O-acetyl-Δ^4-pregnene-17α,21-diol-3,20-dione

$\Delta^{1,4}$-pregnadiene-17α,21-diol-3,20-dione

Vischer et al., Helv. Chim. Acta 38, 1502-7 (1955).

C.A. 50, 5716a (1956).

Rx. 423



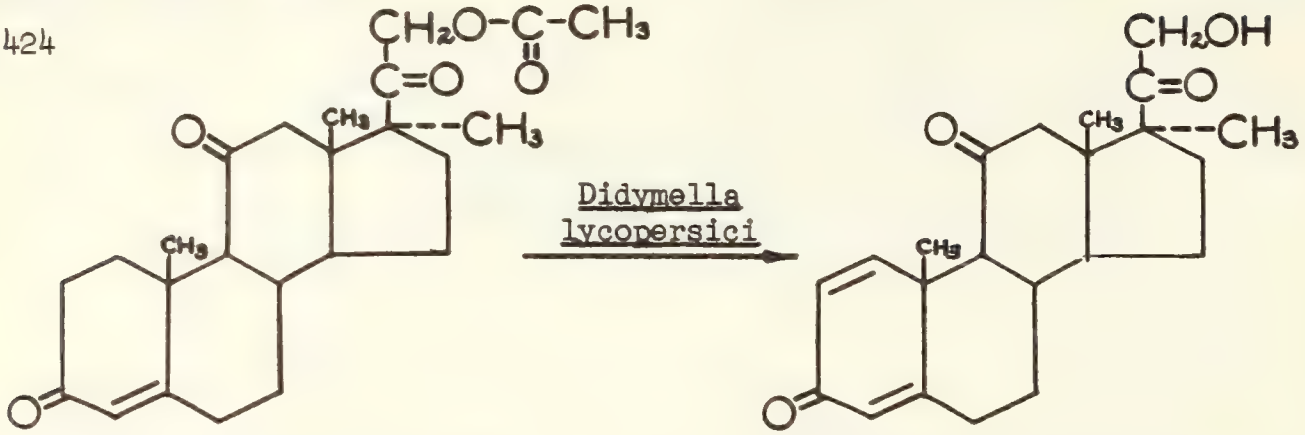
21-O-acetyl-$\Delta^{4,6}$-pregnadiene-21-ol-3,20-dione

$\Delta^{1,4,6}$-pregnatriene-21-ol-3,20-dione

Vischer et al., Helv. Chim. Acta, 38, 1502-7 (1955).

C.A. 50, 5716a (1956).

Rx. 424



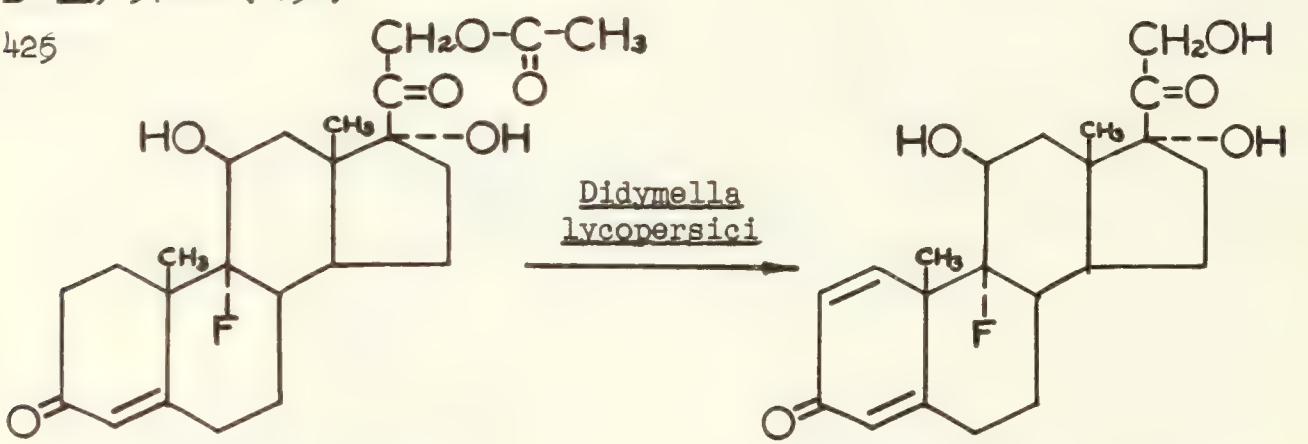
21-O-acetyl-17α-methyl-Δ^4-pregnene-21-ol-3,11,20-trione

17α-methyl-$\Delta^{1,4}$-pregnadiene-21-ol-3,11,20-trione

Vischer et al., Helv. Chim. Acta 38, 1502-7 (1955).

C.A. 50, 5716a (1956).

Rx. 425



21-O-acetyl-9α-fluoro-hydrocortisone

Δ^1-dehydro-9α-fluoro-hydrocortisone

I. Oxidation

e. $-CH_2OH \longrightarrow -COOH$

Kützing, J. prakt. Chem. 11, 385-409 (1837).

Rx. 426

$$CH_3-CH_2OH \xrightarrow{\text{aerobic organisms}} CH_3-COOH$$

ethanol — acetic acid

Pasteur, "Mémoire sur la fermentation acétique." (1864).

Rx. 427

$$CH_3-CH_2OH \xrightarrow{\underline{\text{Acetobacter aceti}}\ (\underline{\text{Mycoderma aceti}})} CH_3-COOH$$

ethanol — acetic acid

Seifert, Zentr. Bakt. Parasitenk. II Abt., 3, 337-49 (1897).
Brit. C.A. 74 [ii], 399 (1898).

Rx. 428

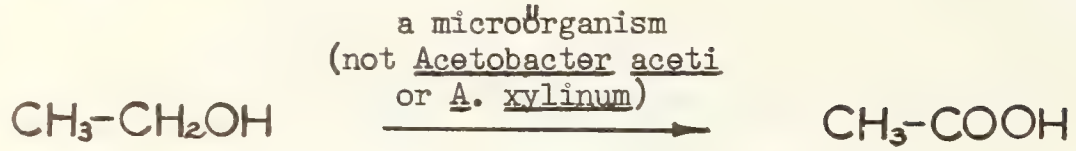
$$CH_3-CH_2OH \xrightarrow{\underline{\text{Acetobacter pasteurianum}};\ (\underline{\text{Bacterium pasteurianum}})\ \underline{\text{A. kützingianum}}\ (\underline{\text{B. kützingianum}})} CH_3-COOH$$

ethanol — acetic acid

Sazerac, Compt. rend. 137, 90-2 (1903).

Brit. C.A. 84 [ii], 606 (1903).

Rx. 429

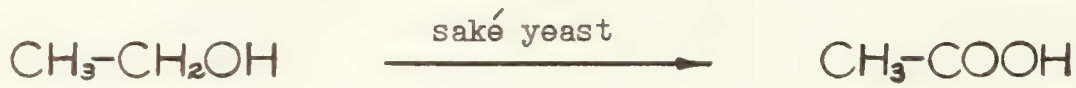


ethanol — acetic acid (approx. 32%)

Yamada, Bull. Agr. Chem. Soc. Japan 3, 76-80; 80-3 (1927).

C.A. 22, 8415 (1928).

Rx. 430

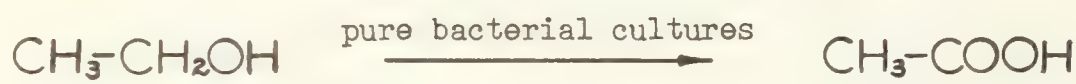


ethanol — acetic acid

Gilvert and Subramanian, J. Ind. Inst. Sci. 8, 147-72 (1928).

C.A. 22, 41426 (1928).

Rx. 431

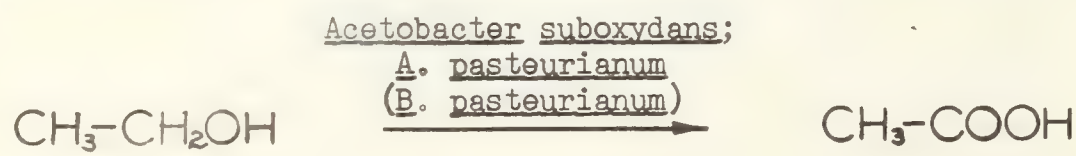


ethanol — acetic acid

Simon, Biochem. Z. 224, 253-91 (1930).

C.A. 24, 53299 (1930).

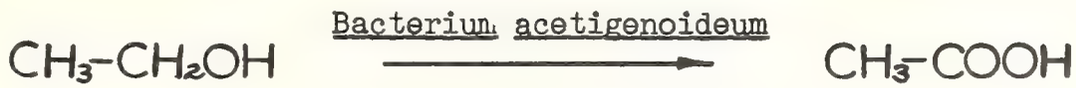
Rx. 432



ethanol — acetic acid

Krehan, Arch. Mikrobiol. 1, 493-536 (1930). See ibid. 3, 277-321 (1932). See C.A. 26, 4076[2] (1932).

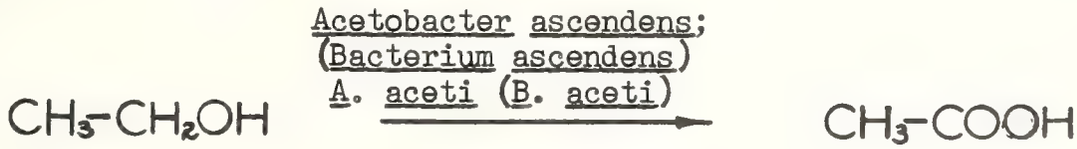
Rx. 433



ethanol — acetic acid (> 90%)

Mosel, Zentr. Bakt. Parasitenk. II Abt. 87, 193-229 (1932). C.A. 27, 1710[2] (1933).

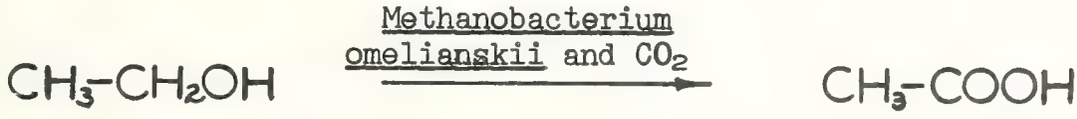
Rx. 434



ethanol — acetic acid

Barker, J. Biol. Chem. 137, 153-67 (1941). C.A. 35, 1439[5] (1941).

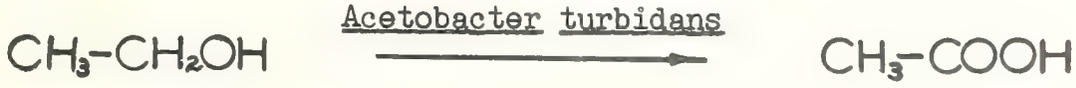
Rx. 435



ethanol — acetic acid (93-96%)

Cosbie et al., J. Inst. Brewing 48, 82-6 (1942). C.A. 36, 5849[4] (1942).

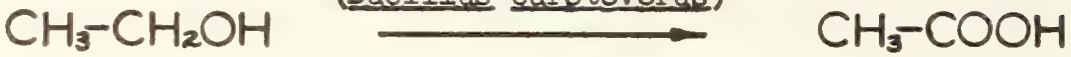
Rx. 436



ethanol — acetic acid

Ikeda, J. Agr. Chem. Soc. Japan 24, 51-5 (1950).
C.A. 45, 7189f (1951).

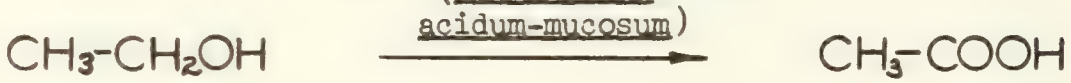
Rx. 437



ethanol — acetic acid

Tosic and Walker, J. Gen. Microbiol. 4, 192-7 (1950).
C.A. 45, 9110a (1951).

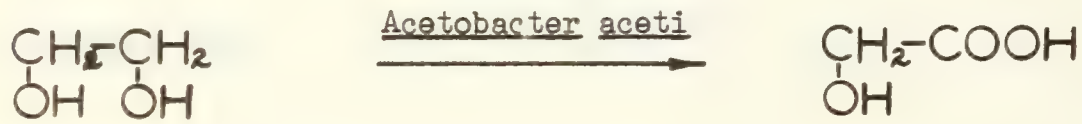
Rx. 438



ethanol — acetic acid

Brown, J. Chem. Soc. 51, 638-42 (1887).

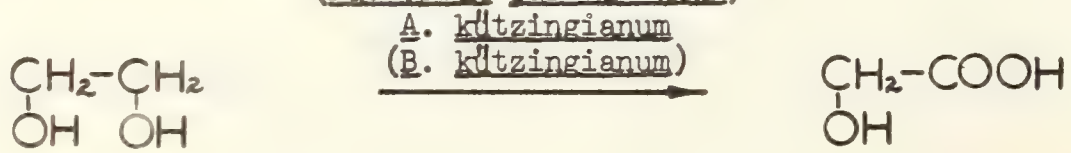
Rx. 439



ethylene glycol (1,2-ethanediol) — glycolic acid

Seifert, Zentr. Bakt. Parasitenk. II Abt., 3, 385-99 (1897).
Brit. C.A. 74 [ii], 399 (1898).

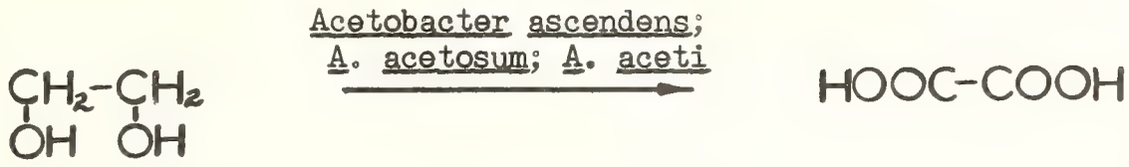
Rx. 440



ethylene glycol — glycolic acid

Banning, Zentr. Bakt. Parasitenk. II Abt. 8, 453-6 (1902).
Brit. C.A. 82 [ii], 469 (1902).

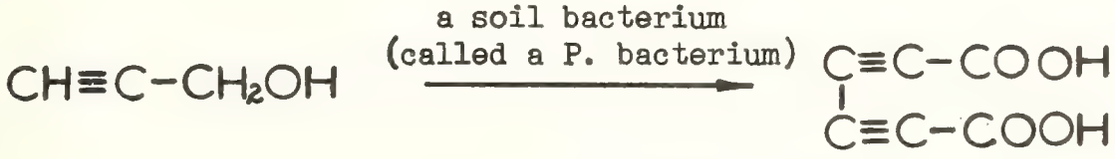
Rx. 441



ethylene glycol — oxalic acid

Hanaoka et al., J. Agr. Chem. Soc. Japan 26, 151-4 (1952).
C.A. 48, 10114f (1954).

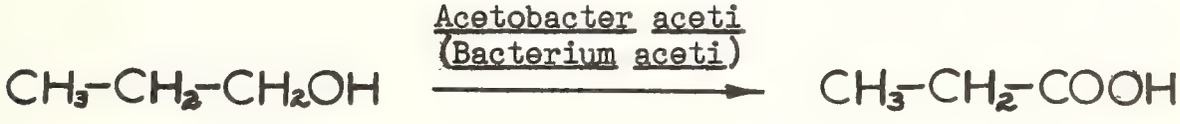
Rx. 442



2-propyn-1-ol — 1,3-butadi-yne-1,4-dicarboxylic acid

Brown, J. Chem. Soc. 49, 172-87 (1886).

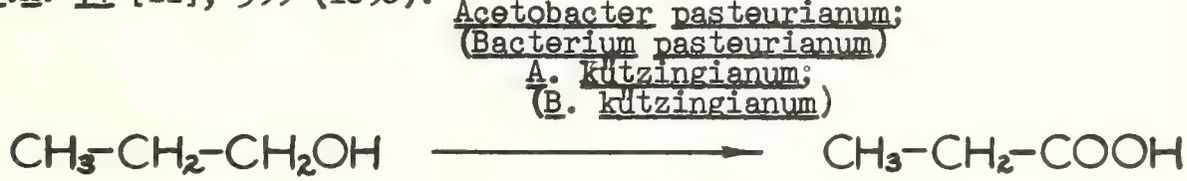
Rx. 443



1-propanol — propionic acid

Seifert, Zentr. Parasitenk. II Abt. 3, 337-49 (1897).
Brit. C.A. 74 [ii], 399 (1898).

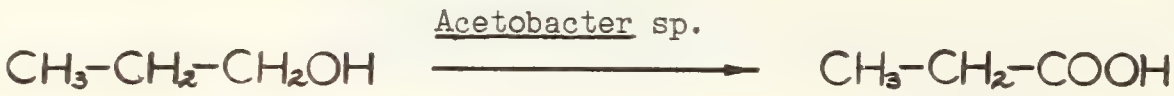
Rx. 444



1-propanol — propionic acid

Visser't Hooft, "Biochemische onderzoekingen over het Geslacht Acetobacter." Thesis, Delft (1925).

Rx. 445

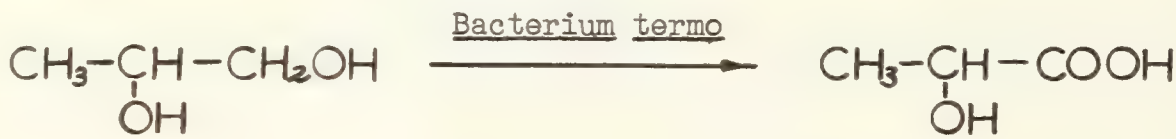


1-propanol — propionic acid (29-75%)

Le Bel, Compt. rend. 92, 532-4 (1881).

Brit. C.A. 40 [ii], 1021 (1881).

Rx. 446

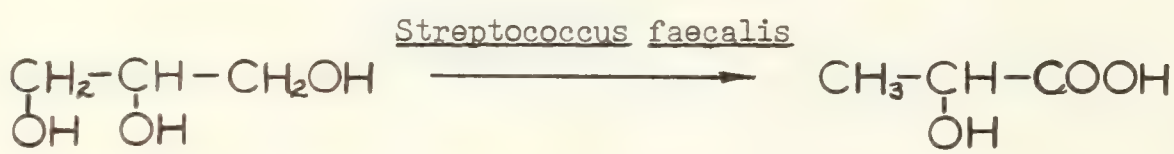


1,2-propanediol (1,2-propylene glycol) — lactic acid

Gunsalus, J. Bacteriol. 54, 239-44 (1947).

C.A. 42, 250a (1948).

Rx. 447

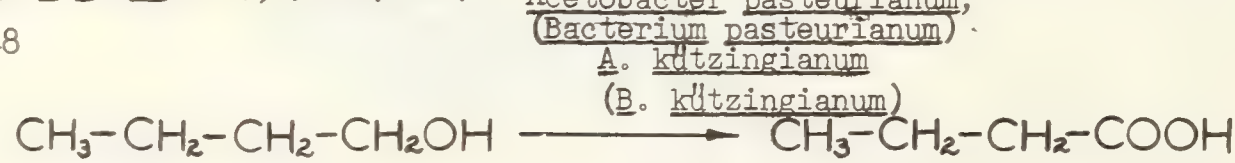


glycerol — lactic acid

Seifert, Zentr. Bakt. Parasitenk. II Abt. 3, 337-49 (1897).

Brit. C.A. 74 [ii], 399 (1898).

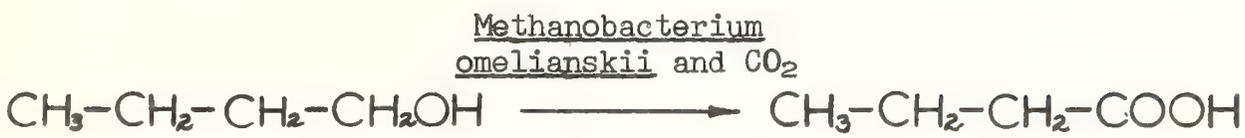
Rx. 448



1-butanol — butyric acid

Barker, J. Biol. Chem. 137, 153-67 (1941).
C.A. 35, 1439[5] (1941).

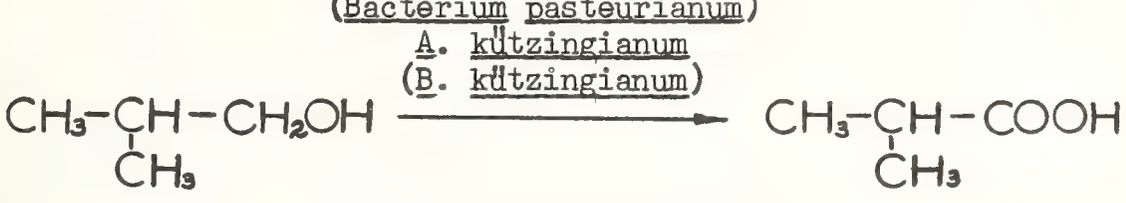
Rx. 449



1-butanol — butyric acid (97%)

Seifert, Zentr. Bakt. Parasitenk. II Abt. 3, 337-49 (1897).
Brit. C.A. 74 [ii], 399 (1898).

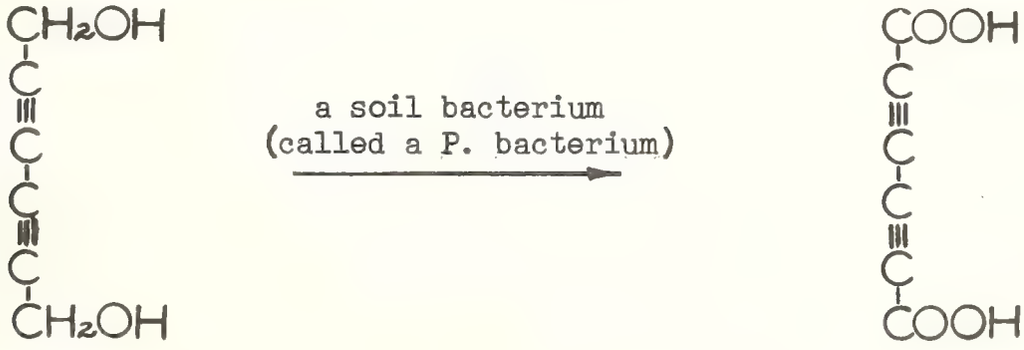
Rx. 450



2-methyl-1-propanol (isobutyl alcohol) — 2-methylpropionic acid (isobutyric acid)

Hanaoka et al., J. Agr. Chem. Soc. Japan 26, 151-4 (1952).
C.A. 48, 10114f (1954).

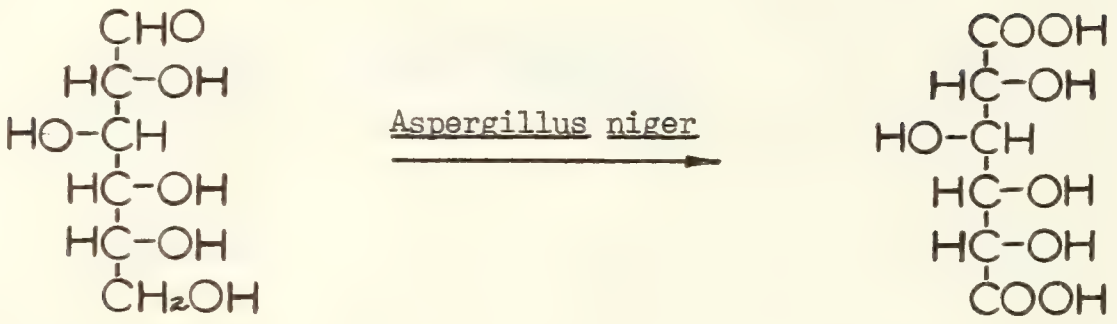
Rx. 451



2,4-hexadi-yne-1,6-diol — product believed to be 1,3-butadi-yne-1,4-dicarboxylic acid

Challenger et al., Nature, 119, 674 (1927).
C.A. 21, 2715[3] (1927).

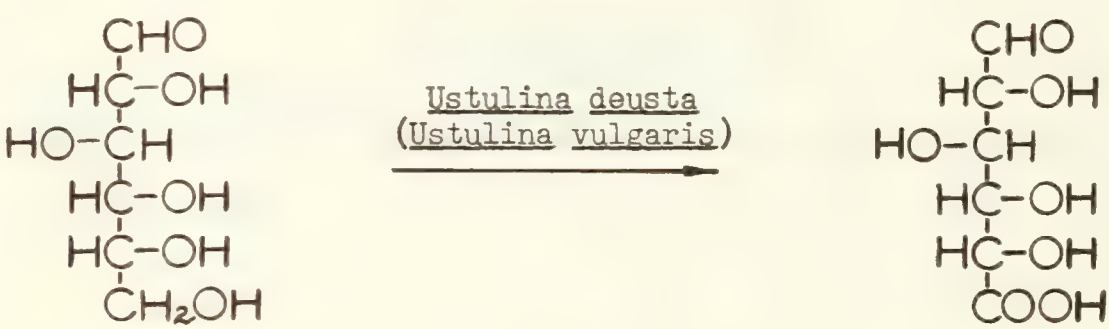
Rx. 452



glucose — saccharic acid

Wünschendorff and Killian, Compt. rend. 187, 572-4 (1928).
C.A. 23, 635[9] (1929).

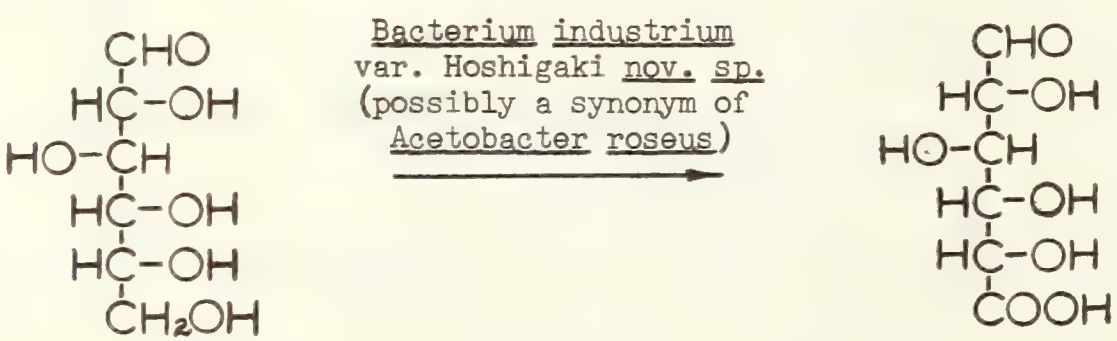
Rx. 453



glucose — glucuronic acid

Takahashi and Asai, Zentr. Bakt. Parasitenk. II Abt. 84, 193-5 (1931).
C.A. 25, 5190[2] (1931).

Rx. 454

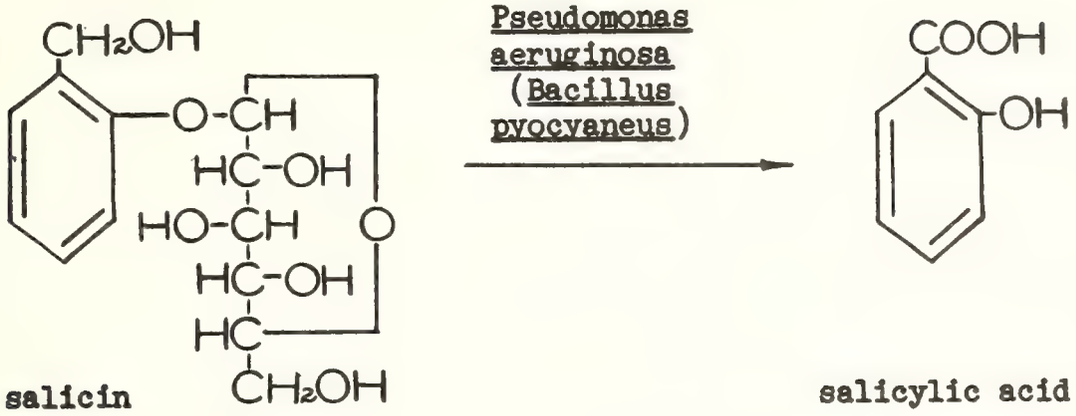


glucose — l-glucuronic acid (25%)

Supniewski, Biochem. Z. 146, 522-35 (1924).

C.A. 19, 3118 (1925).

Rx. 455

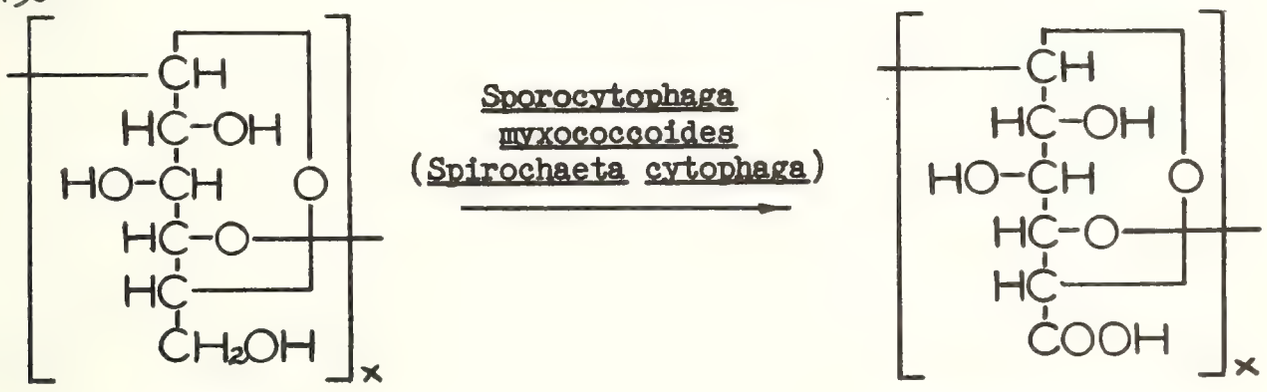


salicin — salicylic acid

Loicjanskaya, Compt. rend. acad. sci. U.R.S.S. 14, 381-4 (1937).

C.A. 31, 62798 (1937).

Rx. 456



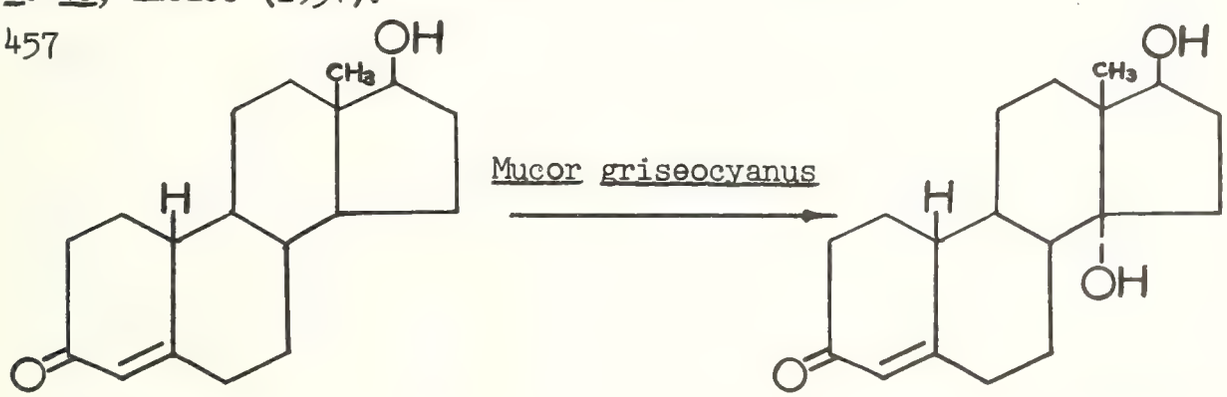
cellulose — polyglucuronic acid

I. Oxidation

f.

Murray and Peterson, U.S. 2,662,089 (Dec. 8, 1953).
C.A. 48, 12818c (1954).

Rx. 457

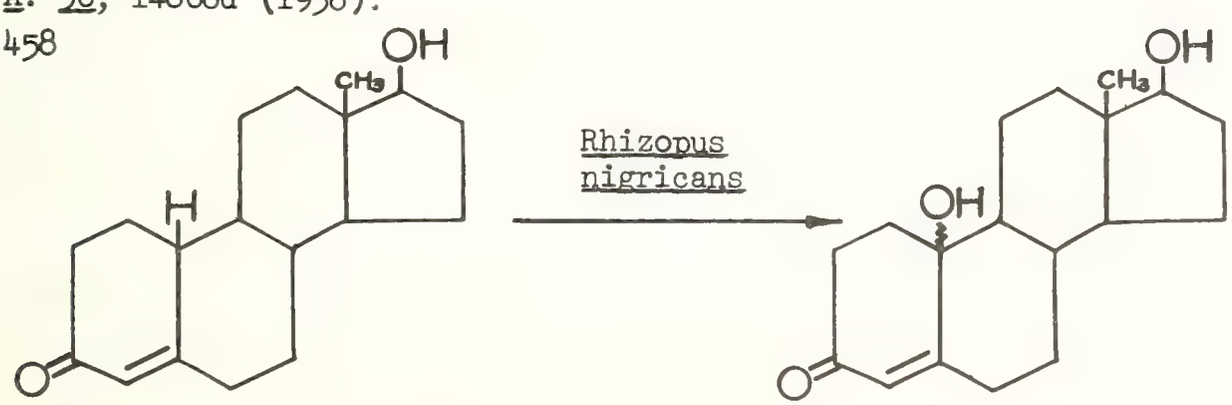


10-normethyltestosterone

14α-hydroxy-10-normethyl-testosterone

Pederson et al., J. Am. Chem. Soc. 78, 1512-13 (1956).
C.A. 50, 14806d (1956).

Rx. 458

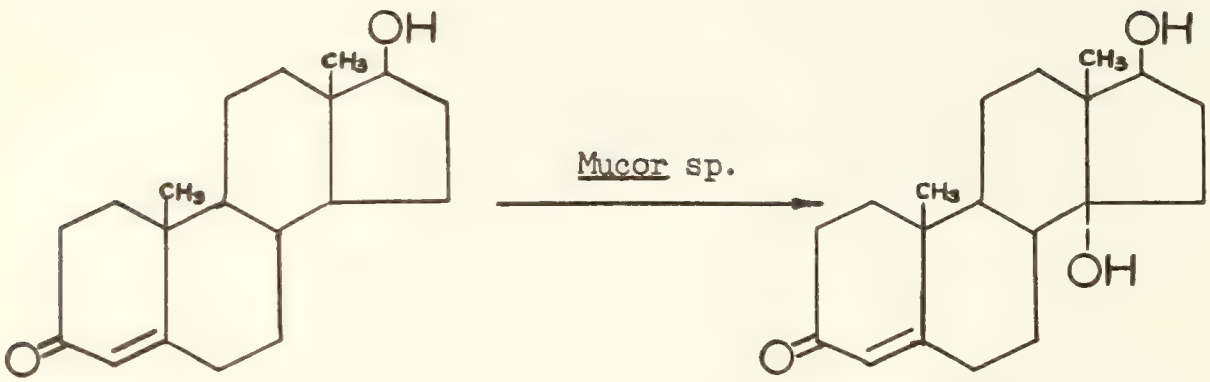


19-nortestosterone

10 X-hydroxy-19-nortestosterone (1.2%)

Meister et al., Abstr. 123rd Mtg. ACS, L.A., Cal., March 1953. p. 5c

Rx. 459

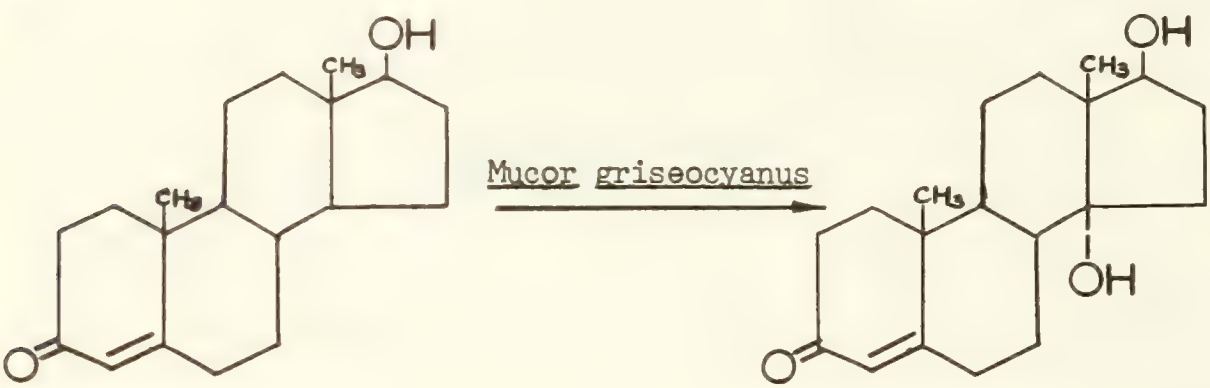


testosterone

14α-hydroxytestosterone
(35%)

Murray and Peterson, U.S. 2,662,089 (Dec. 8, 1953). See Murray and Peterson, U.S. 2,727,910 (Dec. 20, 1955). C.A. 48, 12818c (1954).

Rx. 460

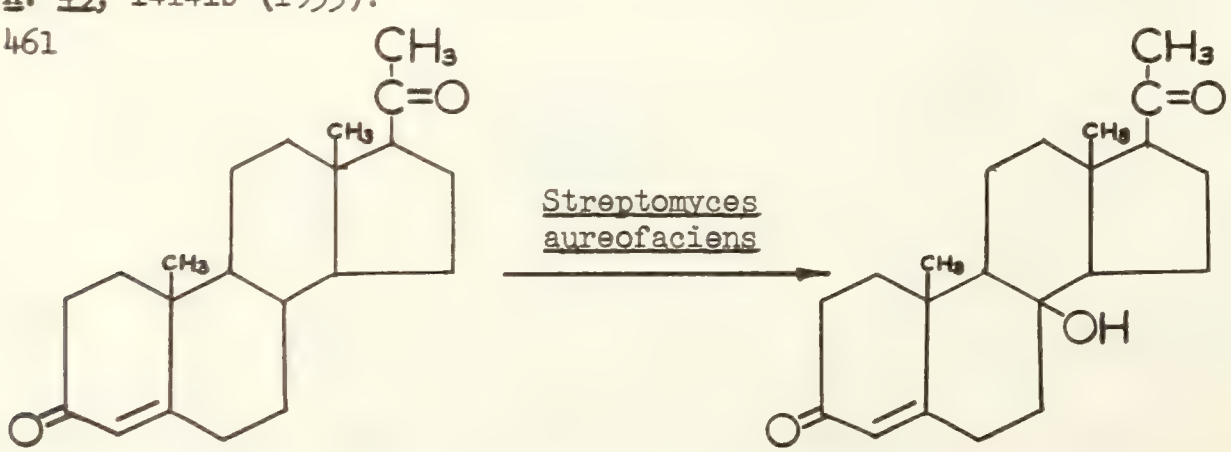


testosterone

14α-hydroxytestosterone
(nearly 100% of crude product)

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955). C.A. 49, 14141b (1955).

Rx. 461



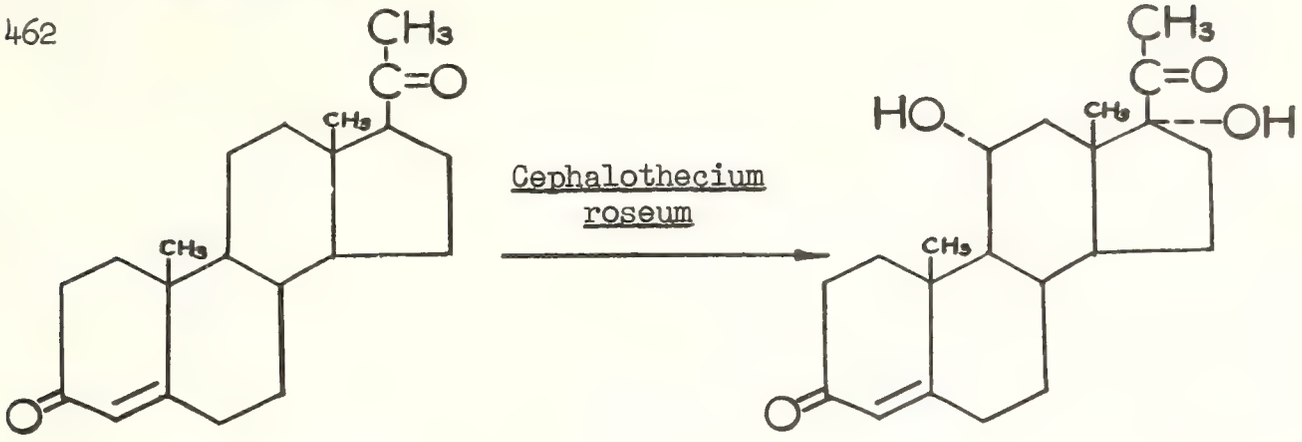
progesterone

possibly 8- (or 9-) hydroxyprogesterone

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 462

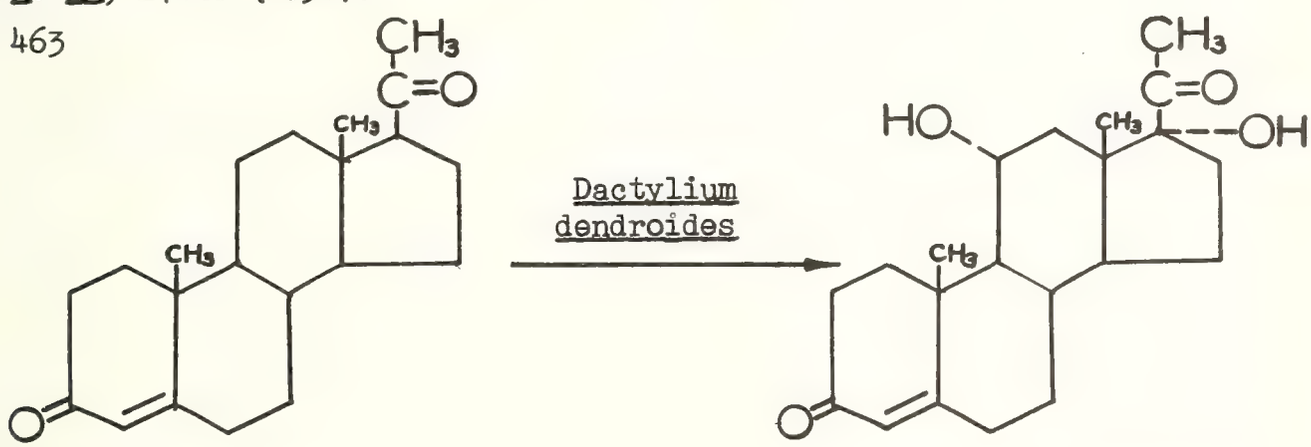


progesterone — 11α,17α-dihydroxyprogesterone

Dulaney et al., Appl. Microbiol. 3, 372-4 (1955).

C.A. 50, 2741c (1956).

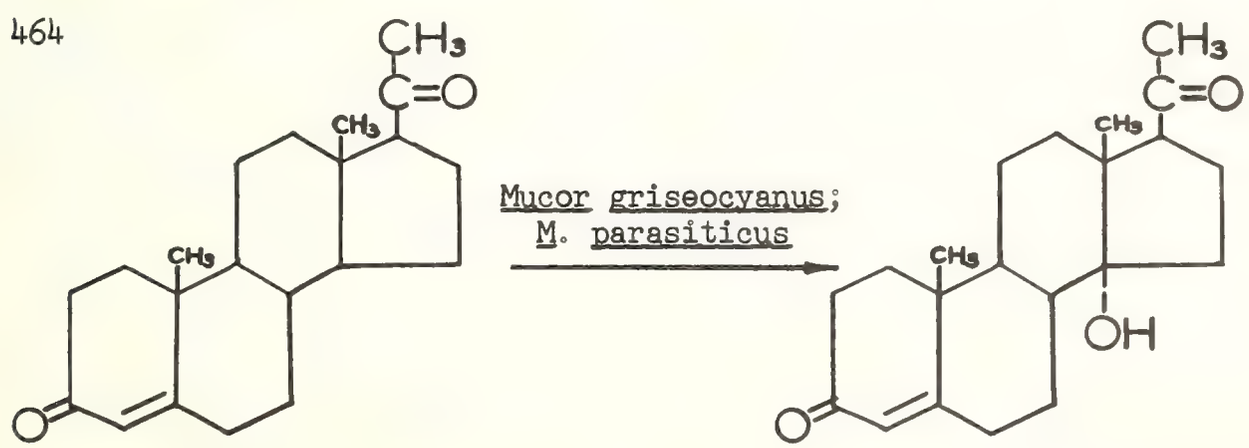
Rx. 463



progesterone — 11α,17α-dihydroxyprogesterone

Meister et al., Abstr. 123rd Mtg. ACS, L. A., Cal., March, 1953. p. 5c

Rx. 464

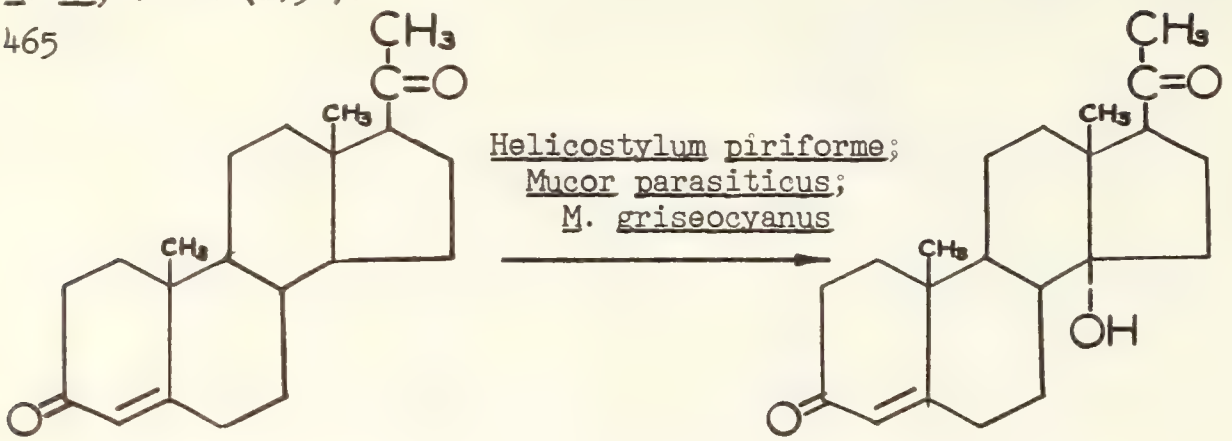


progesterone — 14α-hydroxyprogesterone (15%)

Murray and Peterson, U.S. 2,670,358 (Feb. 23, 1954).

C.A. 48, 6084a (1954).

Rx. 465

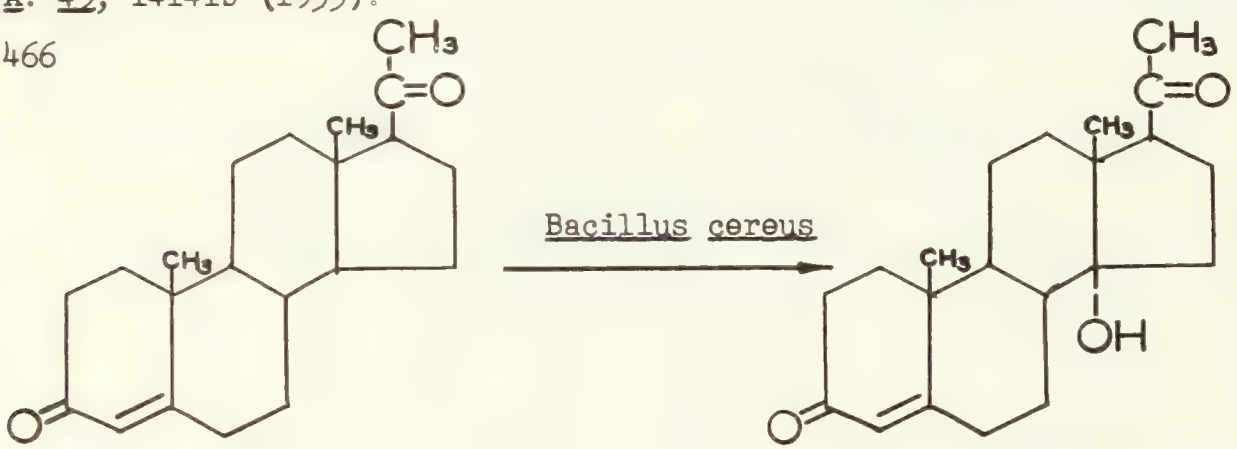


progesterone — 14α-hydroxyprogesterone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 466

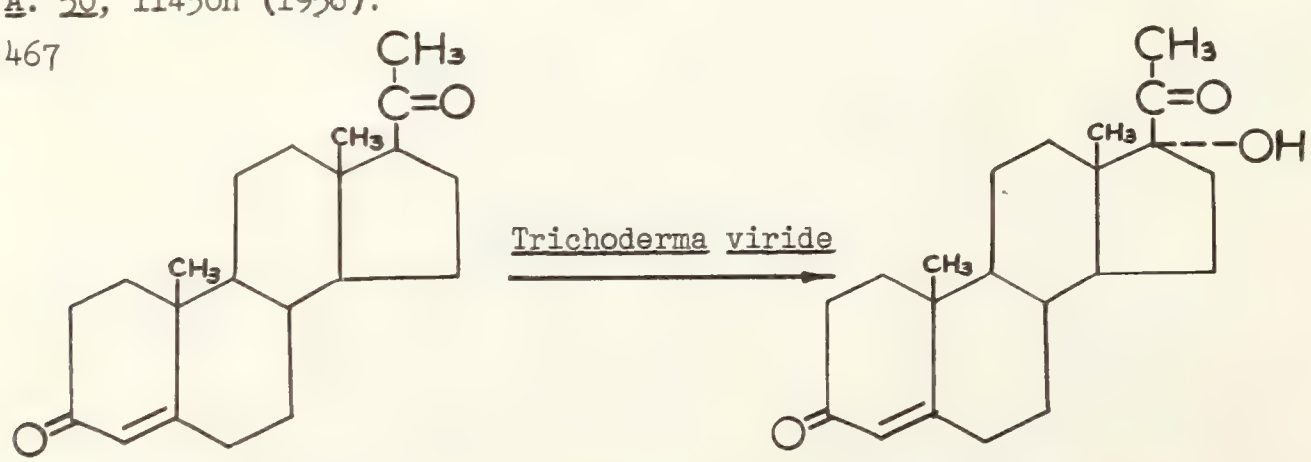


progesterone — 14α-hydroxyprogesterone

McAleer and Dulaney, Arch. Biochem. Biophys. 62, 111-12 (1956).

C.A. 50, 11430h (1956).

Rx. 467

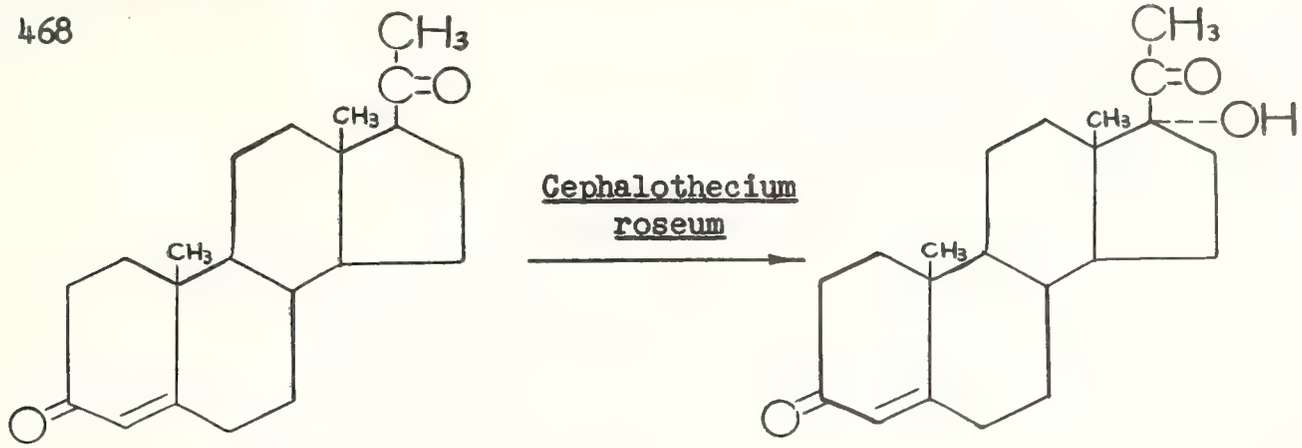


progesterone — 17α-hydroxyprogesterone

Hayano et al., Biochim. et Biophys. Acta 21, 380-1 (1956).

C.A. 50, 15728b (1956).

Rx. 468

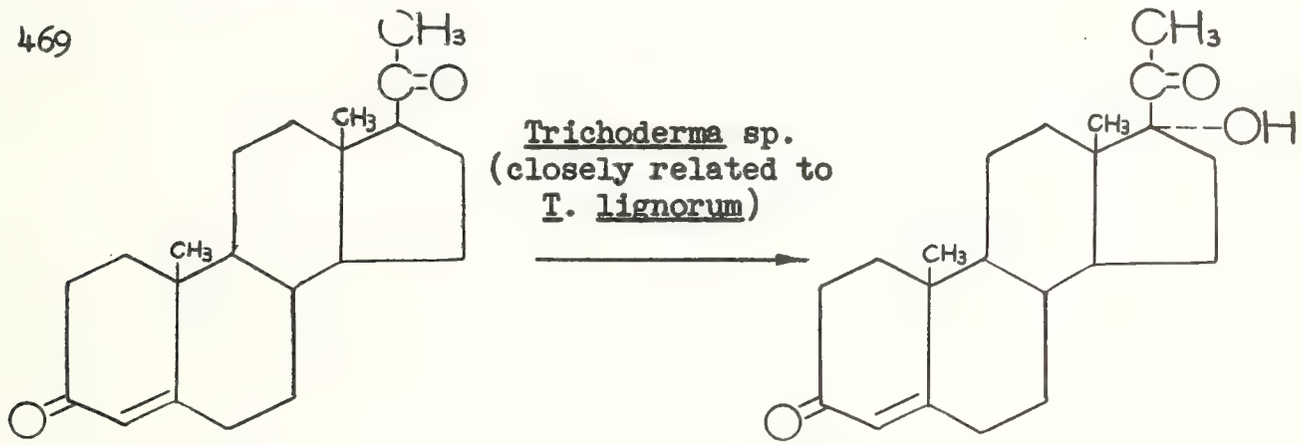


progesterone — 17α-hydroxyprogesterone

Merck and Co., Inc., Brit. 759,731 (Oct. 24, 1956).

C.A. 51, 9723b (1957).

Rx. 469

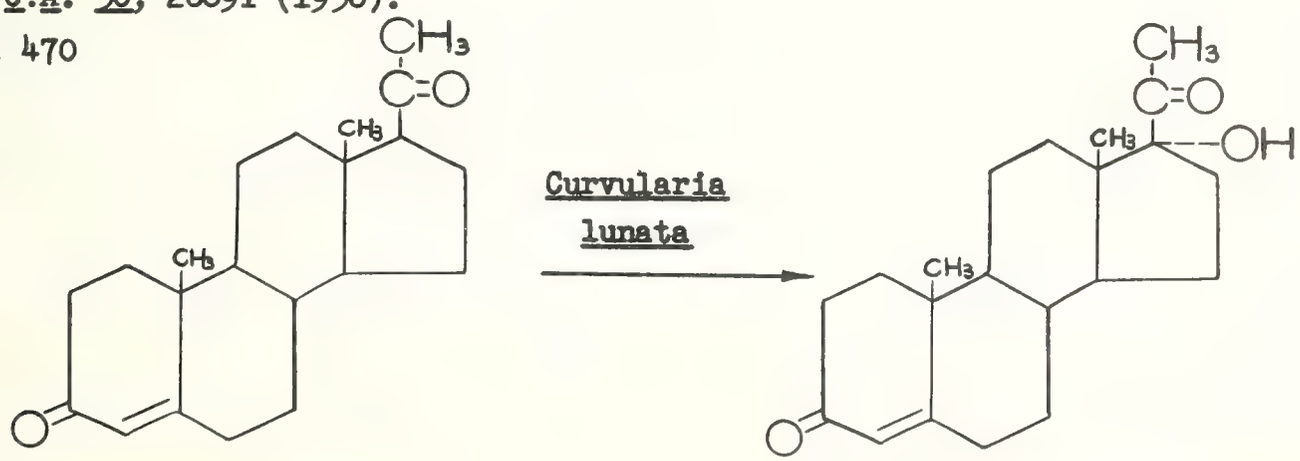


progesterone — 17α-hydroxyprogesterone

Shull et al., U.S. 2,702,812 (Feb. 22, 1955).

C.A. 50, 2689i (1956).

Rx. 470

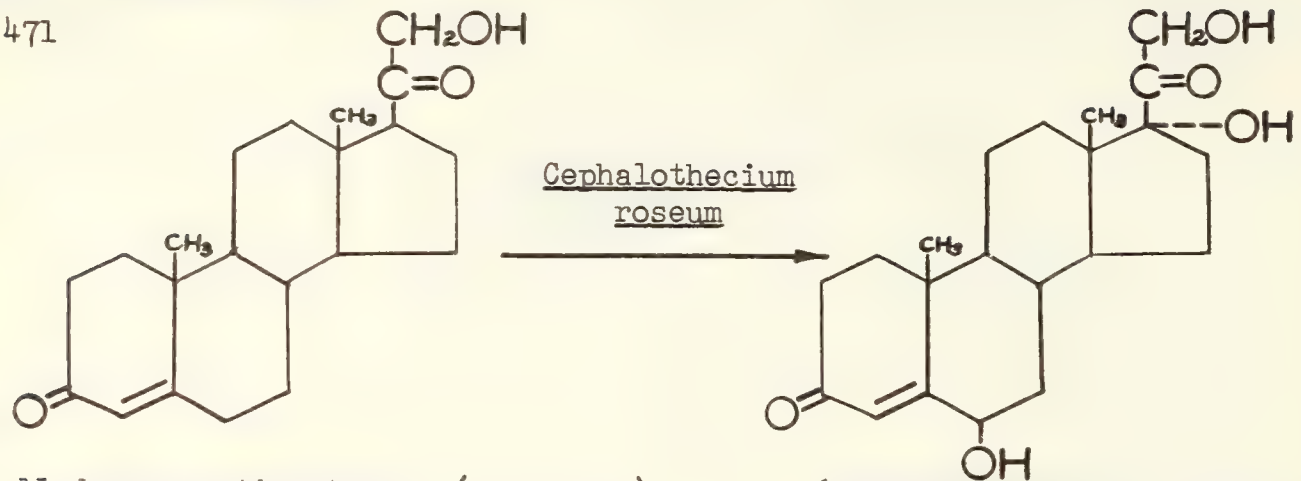


17α-hydroxyprogesterone — 11β,14α,17α-trihydroxy-progesterone (20%)

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 471



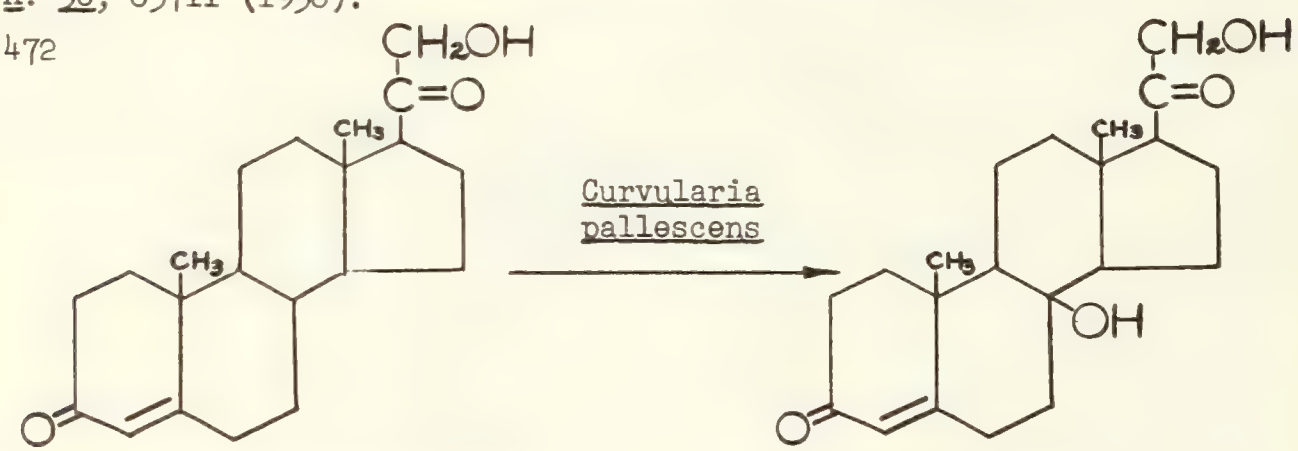
11-desoxycorticosterone (cortexone)

6β,17α-dihydroxy-11-desoxy-corticosterone

Vischer et al., in Wettstein, Experientia 11, 465-79 (1955).

C.A. 50, 6571i (1956).

Rx. 472



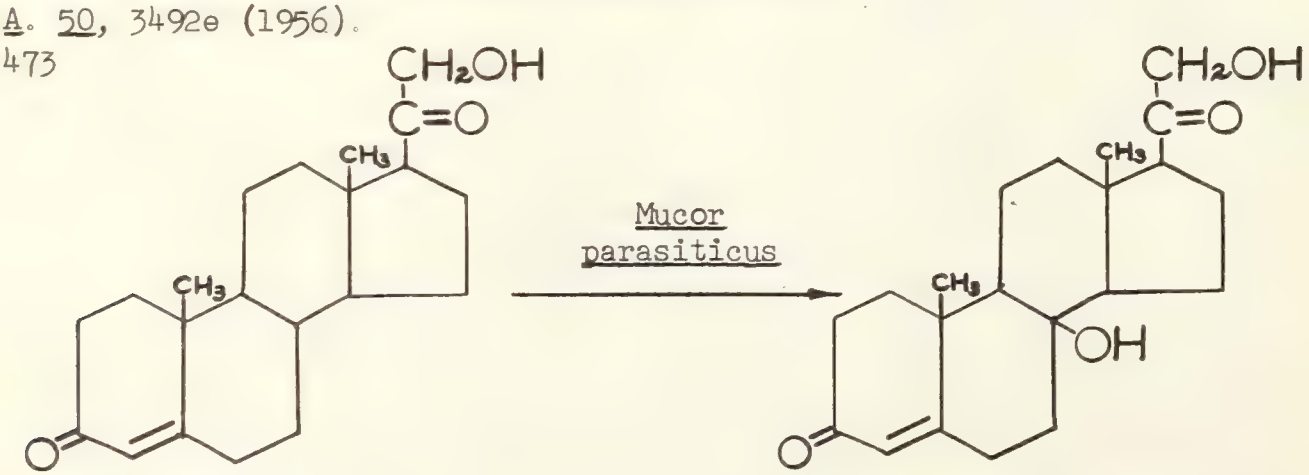
11-desoxycorticosterone

possibly 8β-hydroxy-11-desoxy-corticosterone

Meister, in Stone et al., J. Am. Chem. Soc. 77, 3926-7 (1955).

C.A. 50, 3492e (1956).

Rx. 473



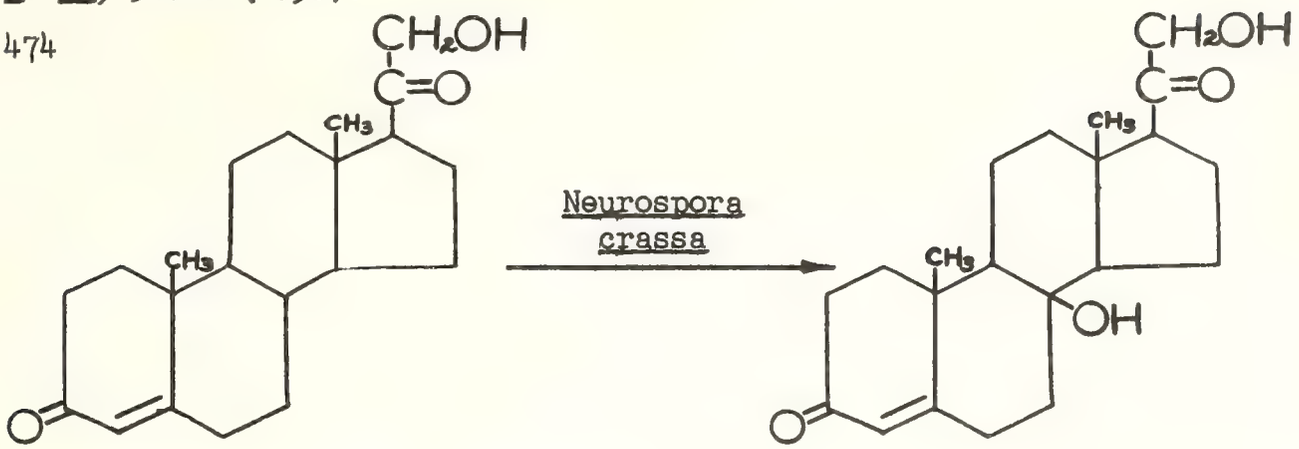
11-desoxycorticosterone

possibly 8β-hydroxy-11-desoxy-corticosterone

Stone et al., J. Am. Chem. Soc. 77, 3926-7 (1955).

C.A. 50, 3492e (1956).

Rx. 474

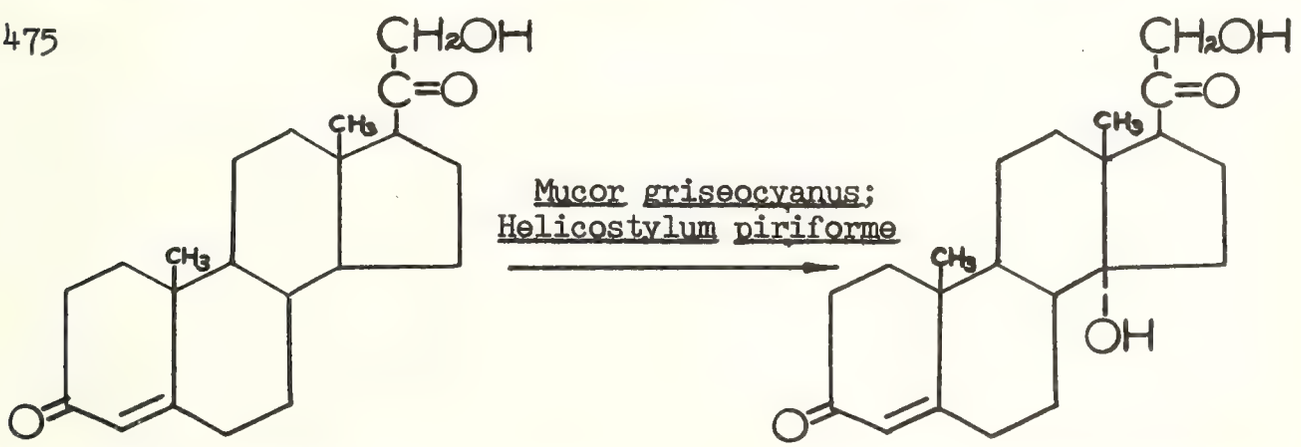


11-desoxycorticosterone (cortexone)

possibly 8β (or 9α-)hydroxy -11-desoxycorticosterone

Meister et al., Abstr. 123rd Mtg. ACS, L.A., Cal., March, 1953, p. 5c

Rx. 475

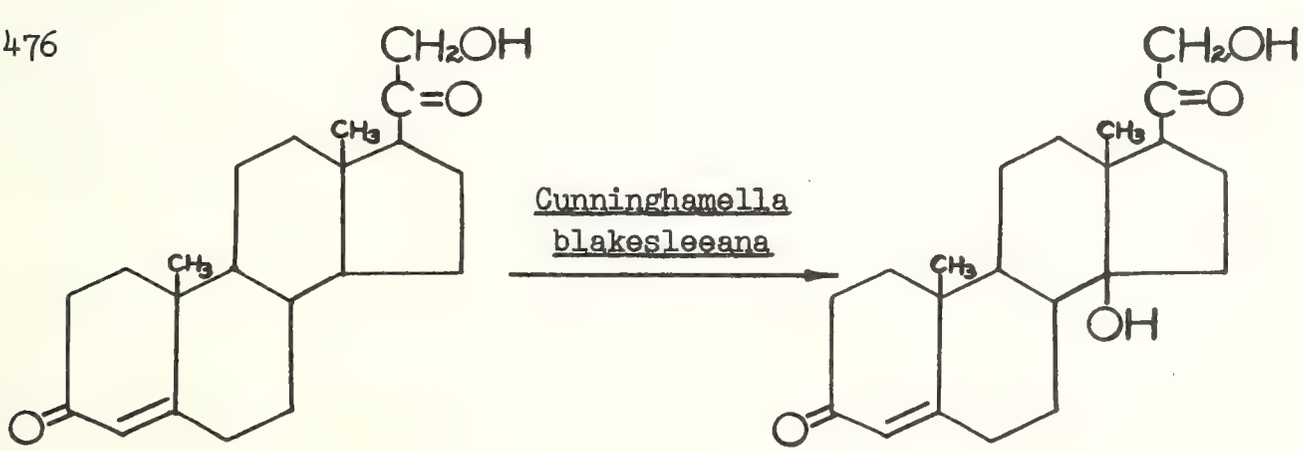


11-desoxycorticosterone (or acetate)

14α-hydroxy-11-desoxycortico-sterone (30-50%)

Mann et al., Federation Proc. 14, 251 (1955).

Rx. 476



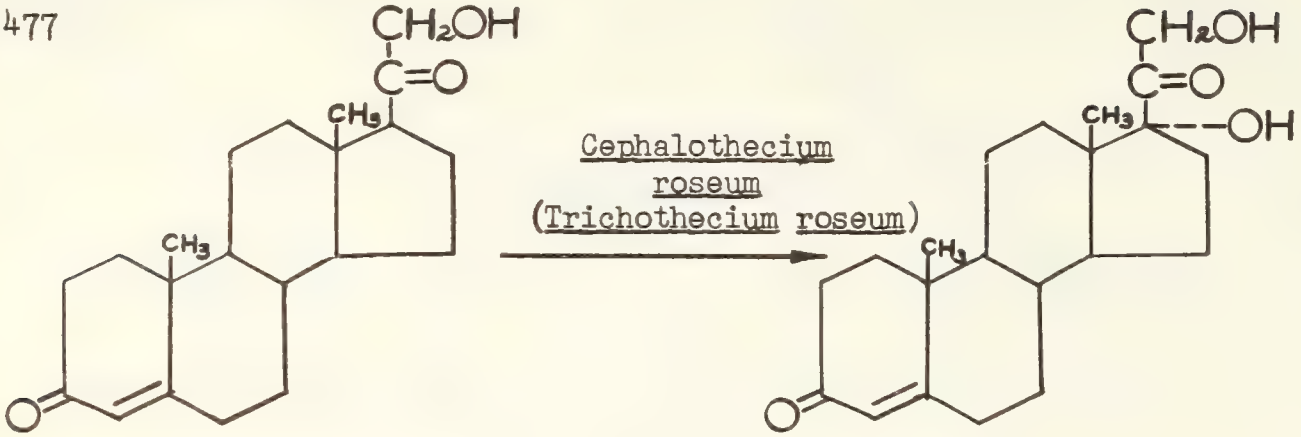
11-desoxycorticosterone

14-hydroxy-11-desoxycortico-sterone

Meystre et al., Helv. Chim. Acta 37, 1548-53 (1954).

C.A. 48, 13797d (1954).

Rx. 477



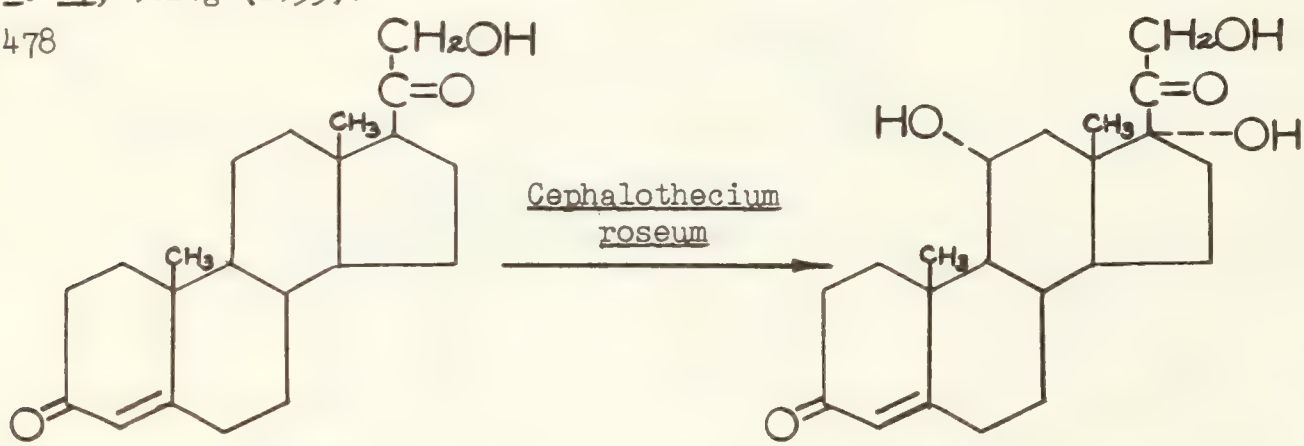
11-desoxycorticosterone

17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd. S)

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 478



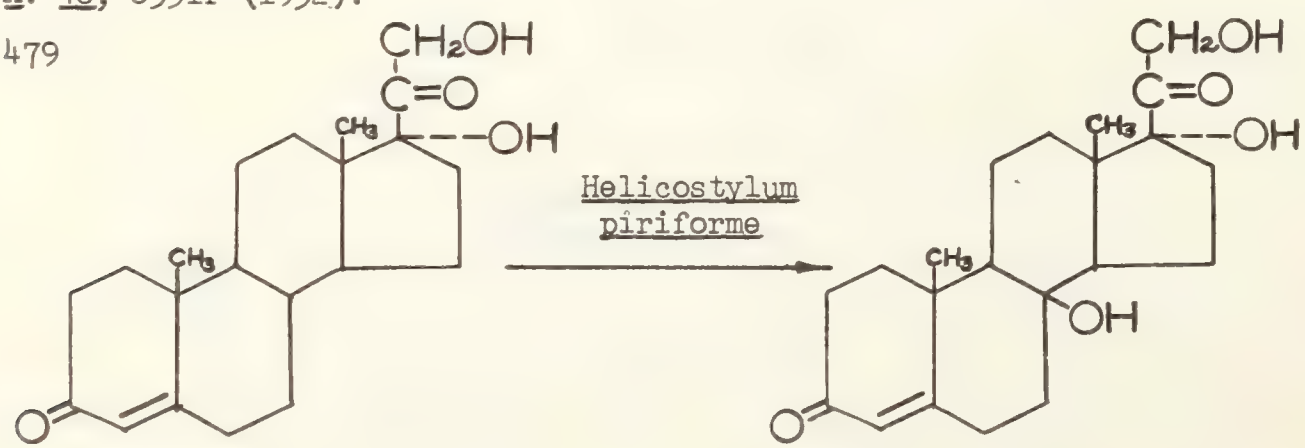
11-desoxycorticosterone

11α,17α-dihydroxy-11-desoxycorticosterone

Murray and Peterson, U.S. 2,602,769 (July 8, 1954).

C.A. 46, 8331f (1952).

Rx. 479

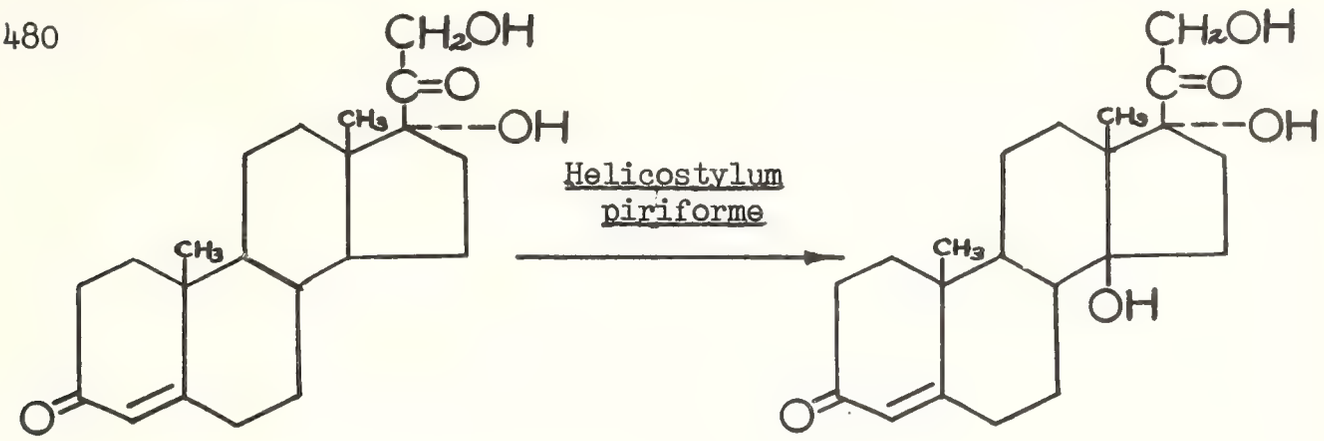


17α-hydroxy-11-desoxycorticosterone

8,17α-dihydroxy-11-desoxycorticosterone (approx. 8%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952). See Murray and Peterson, U.S. 2,673,866 (Mar. 30, 1954).
C.A. 46, 8331f (1952).

Rx. 480

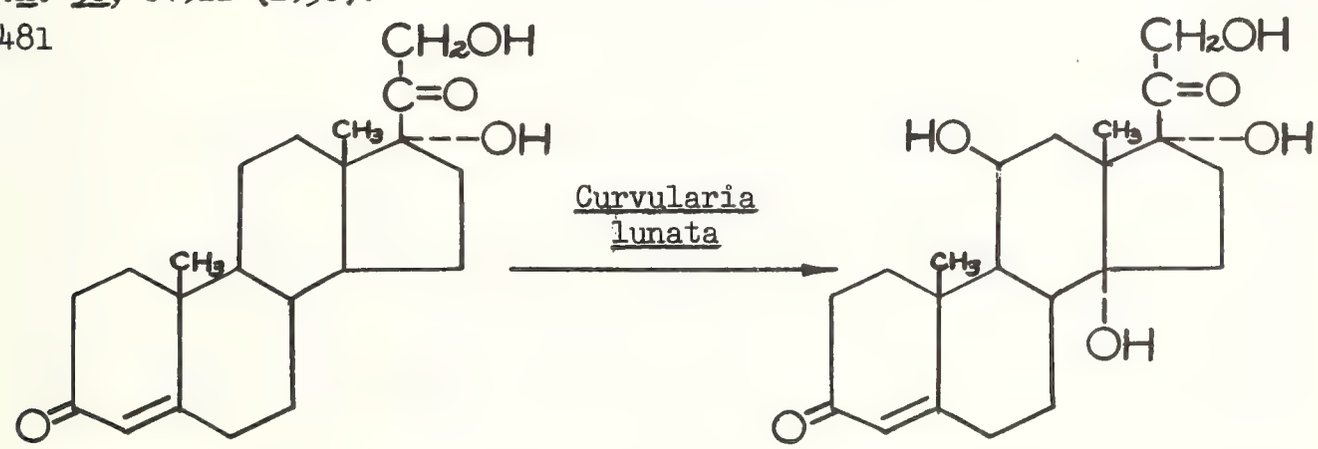


17α-hydroxy-11-desoxycorticosterone

14,17α-dihydroxy-11-desoxycorticosterone

Agnello et al., J. Am. Chem. Soc. 77, 4684-5 (1955).
C.A. 50, 6491i (1956).

Rx. 481

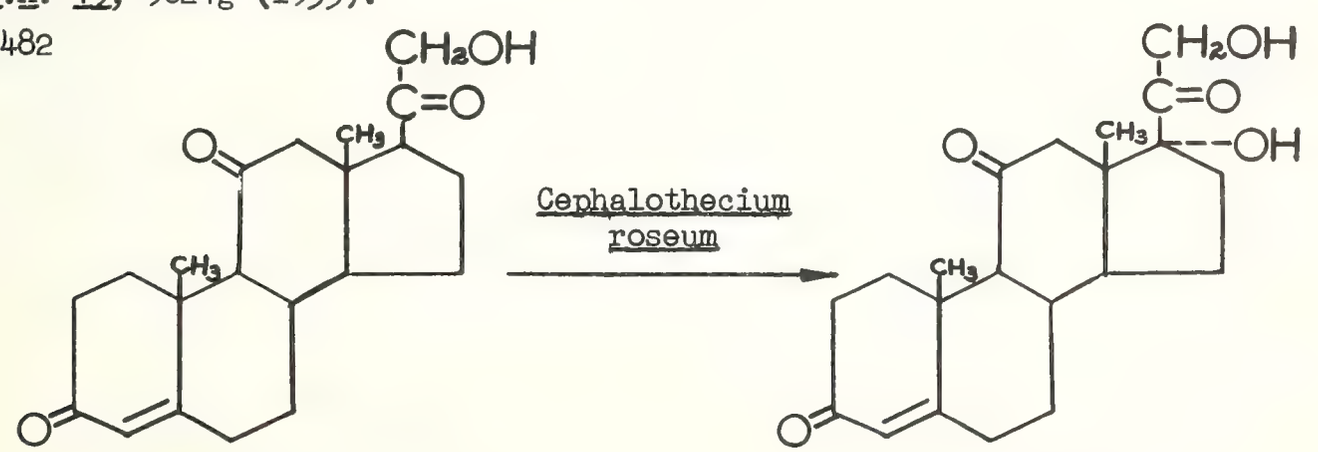


17α-hydroxy-11-desoxycorticosterone

14α-hydroxyhydrocortisone

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).
C.A. 49, 9024g (1955).

Rx. 482



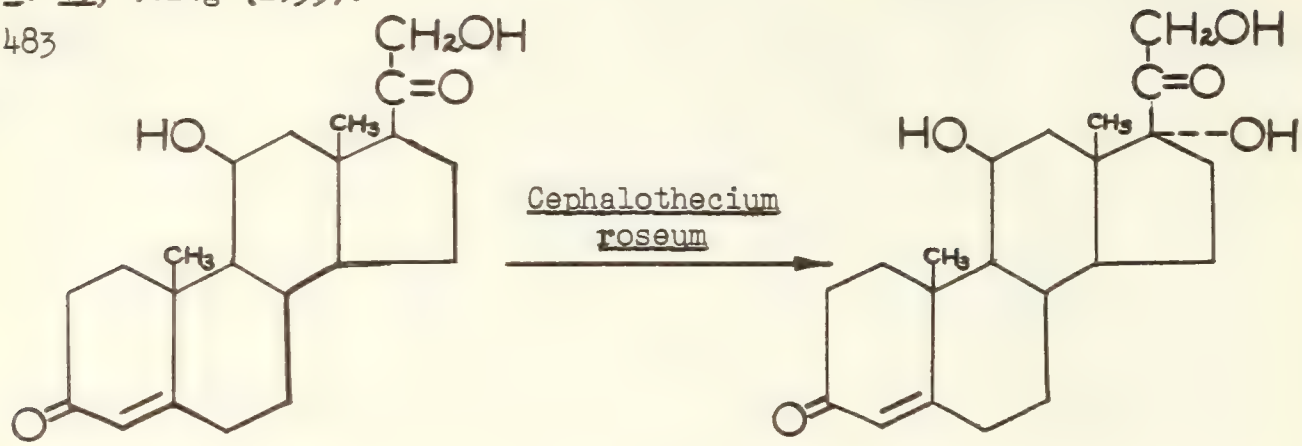
11-dehydrocorticosterone

cortisone

Meister et al., J. Am. Chem. Soc. 76, 4050-1 (1954).

C.A. 49, 9024g (1955).

Rx. 483



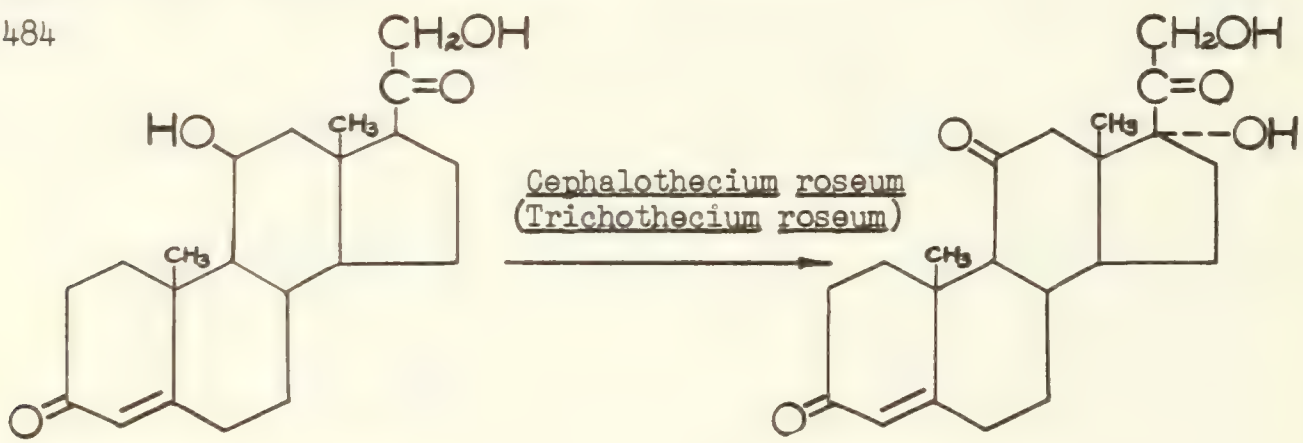
corticosterone

17α-hydroxycorticosterone
(hydrocortisone)

Meystre et al., Helv. Chim. Acta 37, 1548-53 (1954).

C.A. 48, 13797d (1954).

Rx. 484



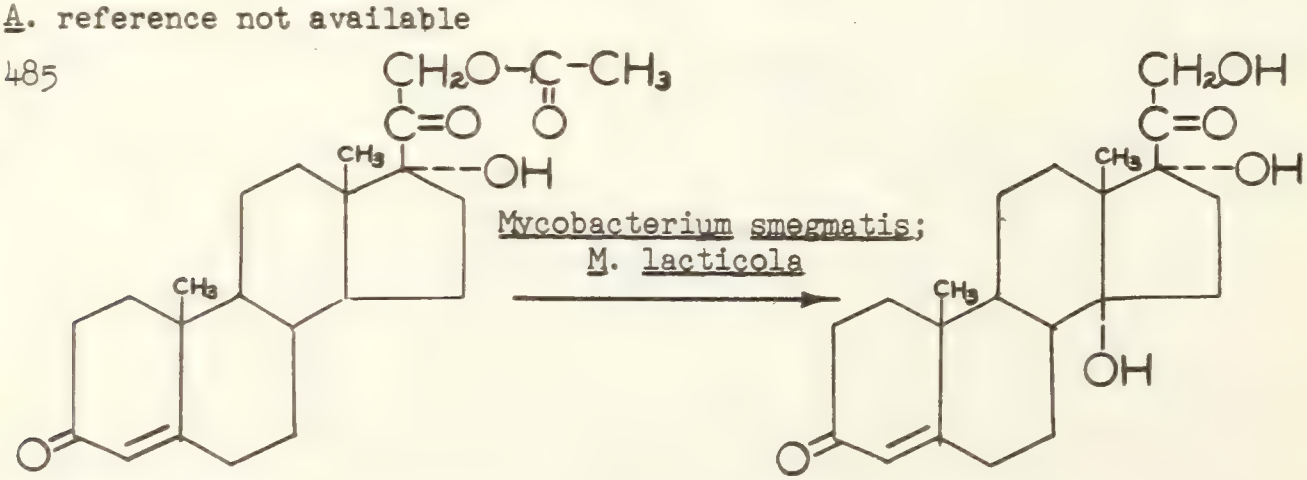
corticosterone

cortisone

Shull and Kita, Belg. 538,327 (May 21, 1955).

C.A. reference not available

Rx. 485



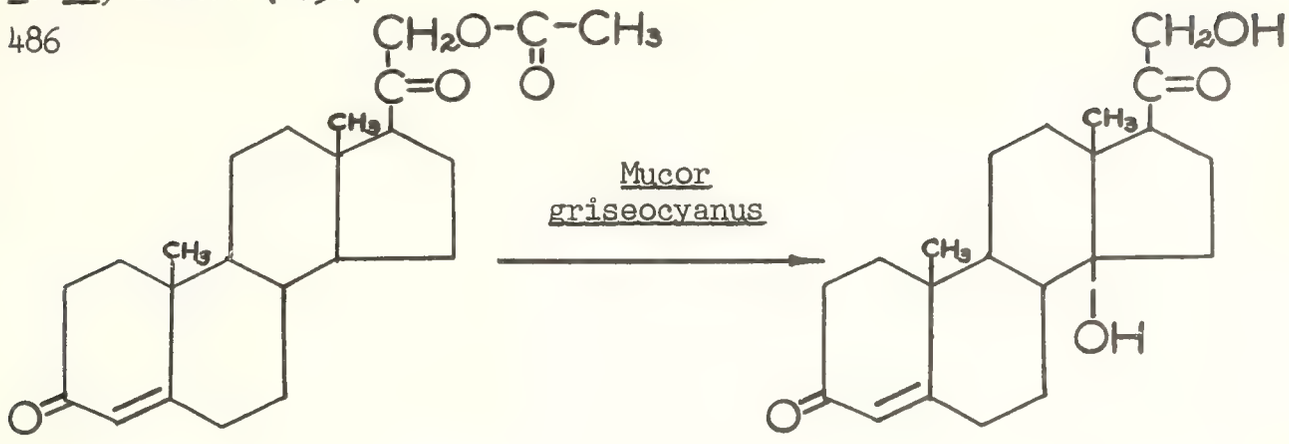
21-O-acetyl-17α-hydroxy-
11-desoxycorticosterone

14α,17α-dihydroxy-11-
desoxycorticosterone

Murray and Peterson, U.S. 2,727,911 (Dec. 20, 1955).

C.A. 50, 10818a (1956).

Rx. 486



21-O-acetyl-11-desoxy-corticosterone

14α-hydroxy-11-desoxy-corticosterone (approx. 25%)

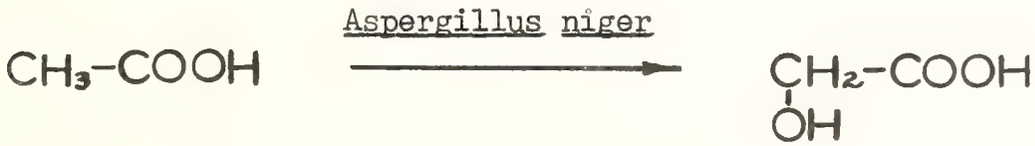
I. Oxidation

9. $-CH_3 \longrightarrow -CH_2OH$

Challenger et al., J. Chem. Soc., 200-8 (1927).

C.A. 21, 1248[6] (1927).

Rx. 487



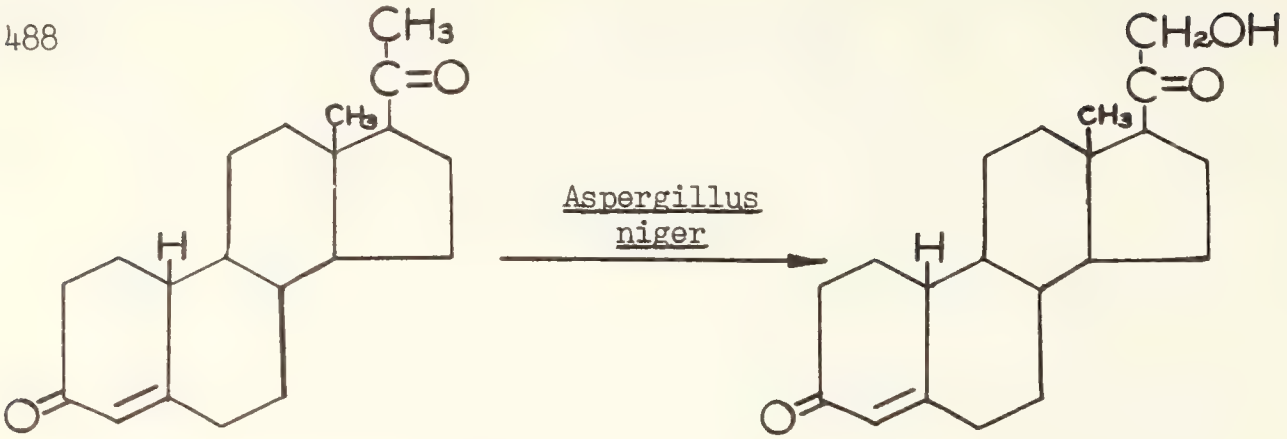
acetic acid

glycolic acid (approx. 9%)

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 488



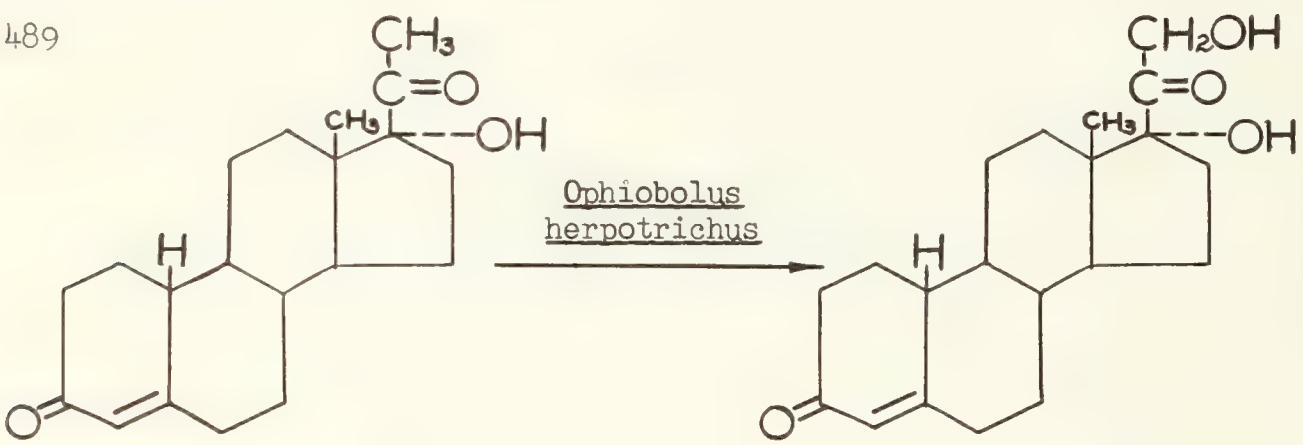
19-norprogesterone

19-nor-11-desoxycorticosterone

Zaffaroni et al., J. Am. Chem. Soc. 76, 6210-11 (1954).

C.A. 49, 14020g (1955).

Rx. 489



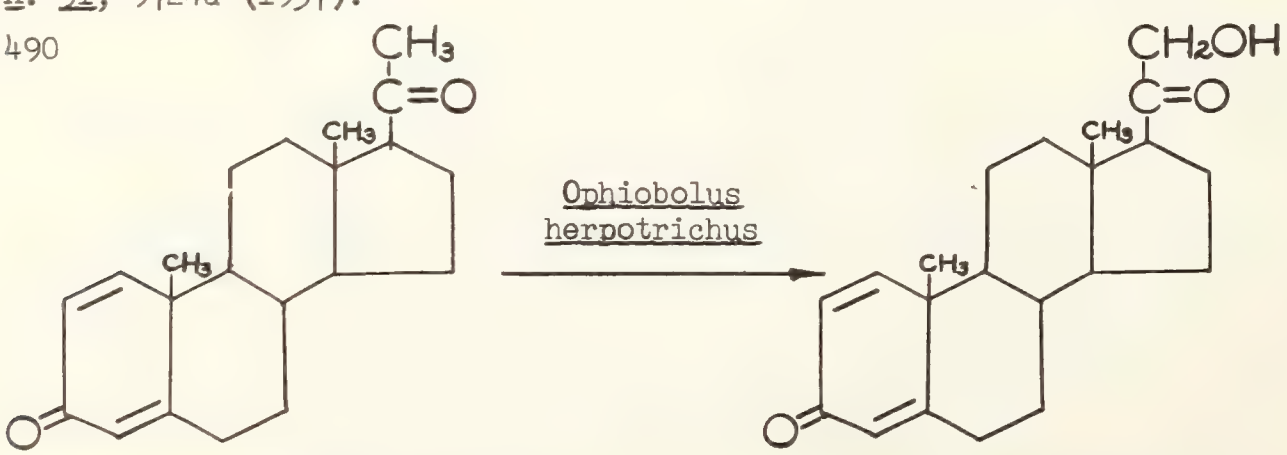
19-nor-17α-hydroxyprogesterone

Δ^4-19-norpregnene-17α,21-diol-3,20-dione

Wettstein et al., U.S. 2,778,776 (Jan. 22, 1957).

C.A. 51, 9724a (1957).

Rx. 490



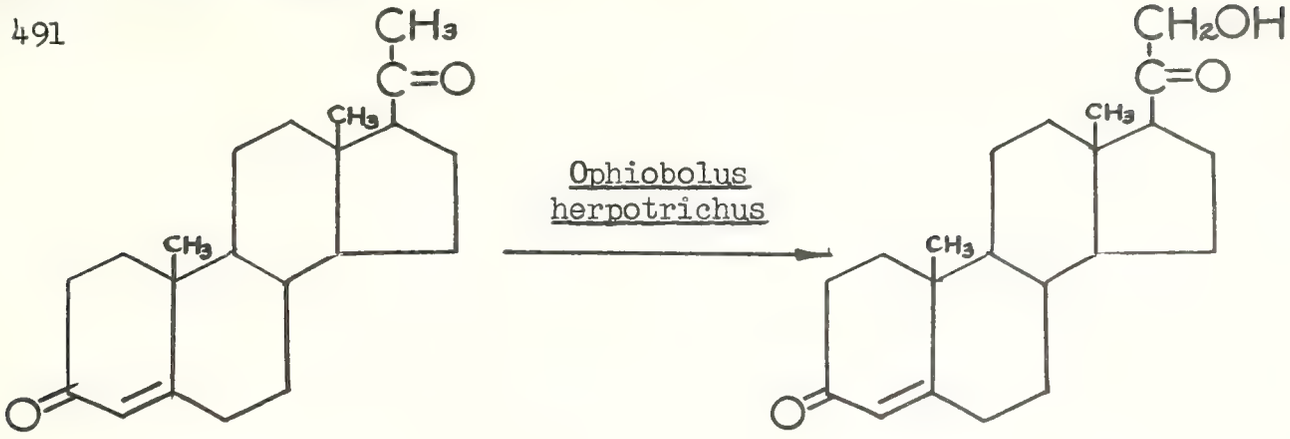
Δ^1-dehydroprogesterone

Δ^1-dehydro-11-desoxy-corticosterone

Meystre et al., Helv. Chim. Acta 37, 1548-53 (1954).

C.A. 48, 13797d (1954).

Rx. 491



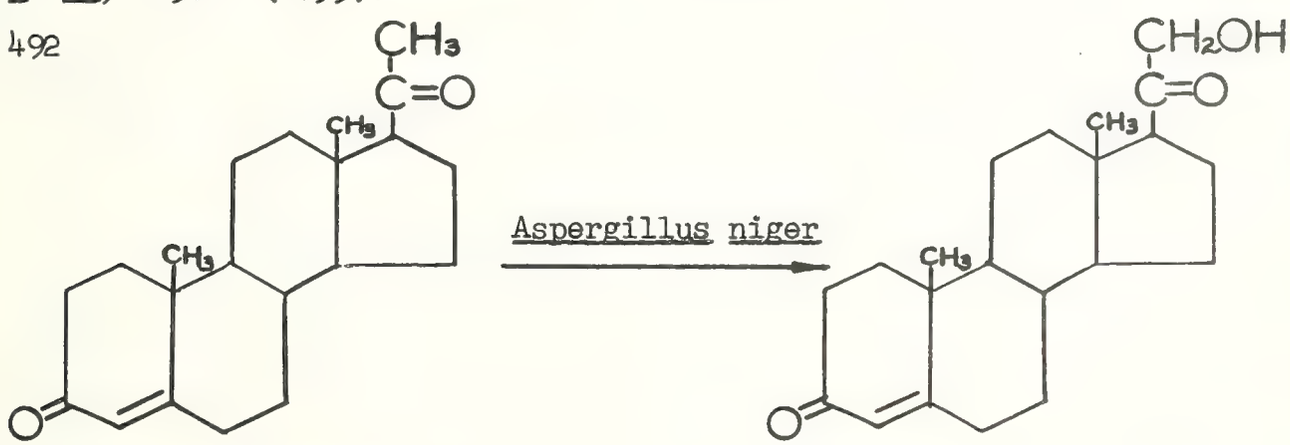
progesterone

11-desoxycorticosterone
(60%)

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 492



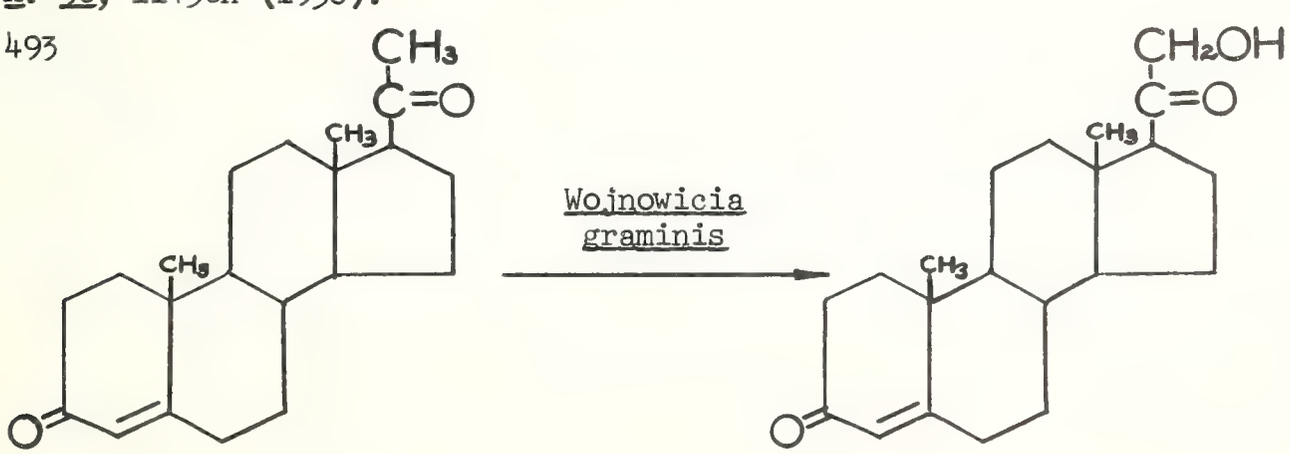
progesterone

11-desoxycorticosterone

McAleer and Dulaney, Arch. Biochem. Biophys. 62, 109-10 (1956).

C.A. 50, 11430h (1956).

Rx. 493



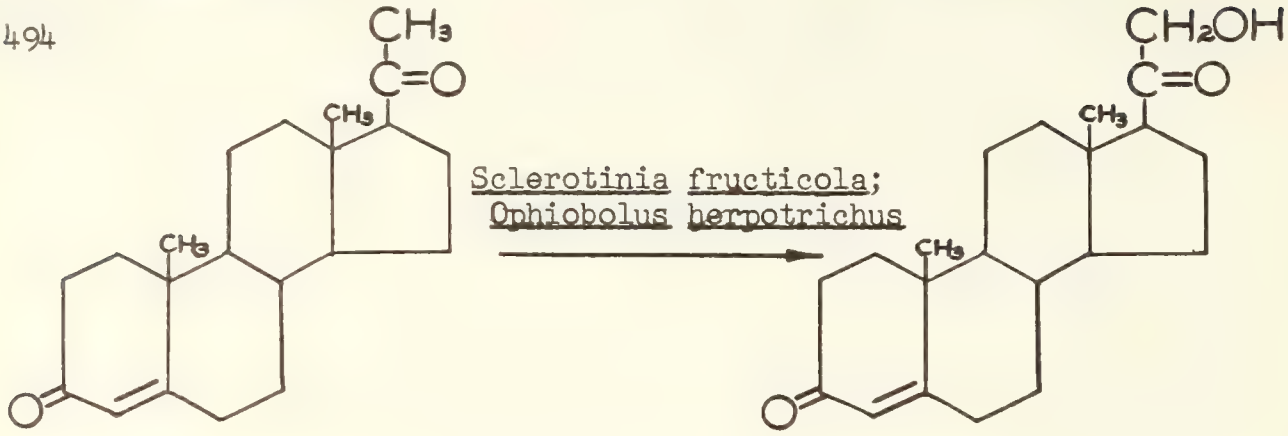
progesterone

11-desoxycorticosterone
(35-45%)

Wettstein et al., U.S. 2,778,776 (Jan. 22, 1957).

C.A. 51, 9724a (1957).

Rx. 494

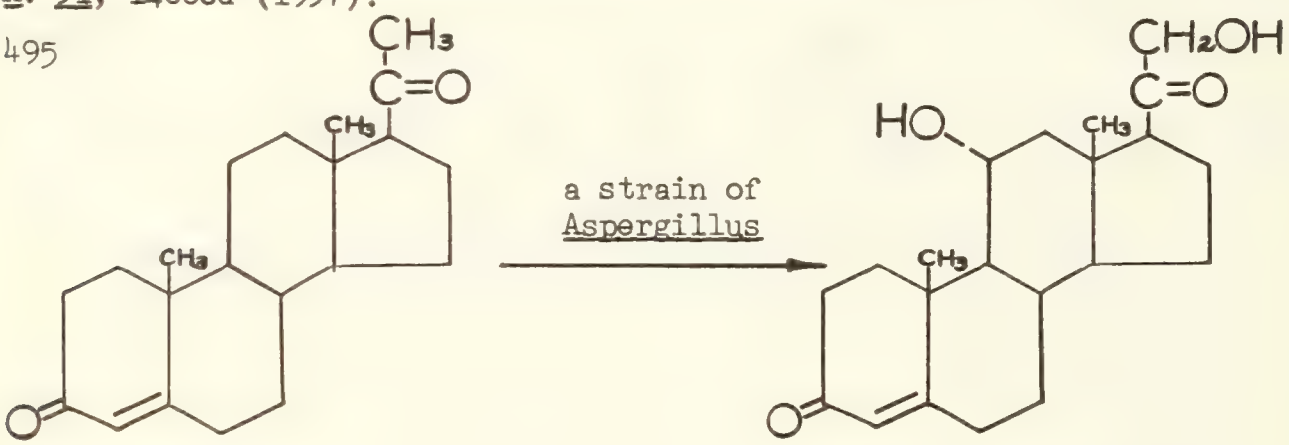


progesterone — 11-desoxycorticosterone

Weisz et al., Naturwissenschaften 43, 39-40 (1956).

C.A. 51, 14008d (1957).

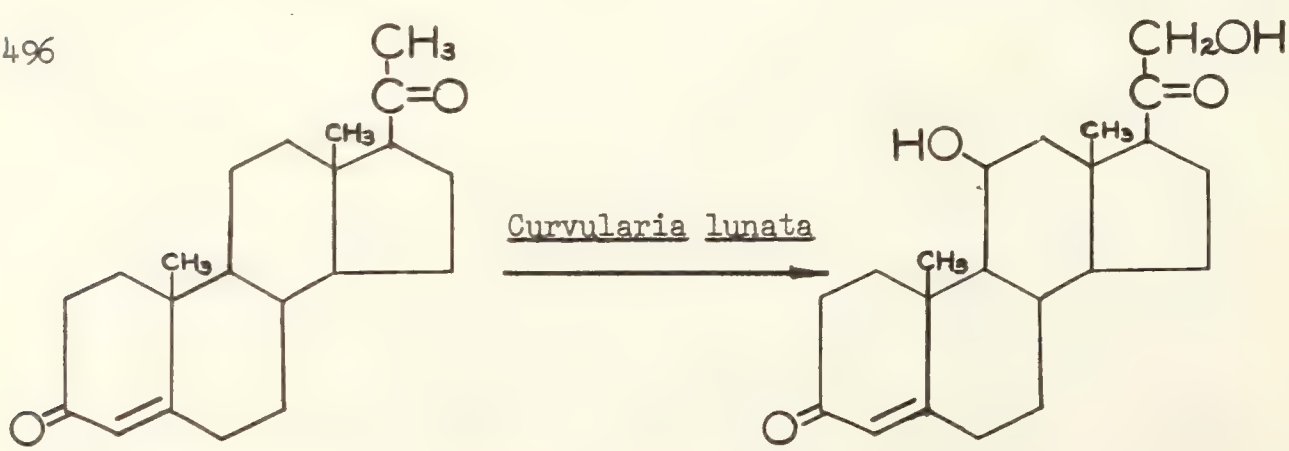
Rx. 495



progesterone — 11α,21-dihydroxyprogesterone (11-epicorticosterone)

Rubin et al., Bact. Proc., 33 (1956).

Rx. 496

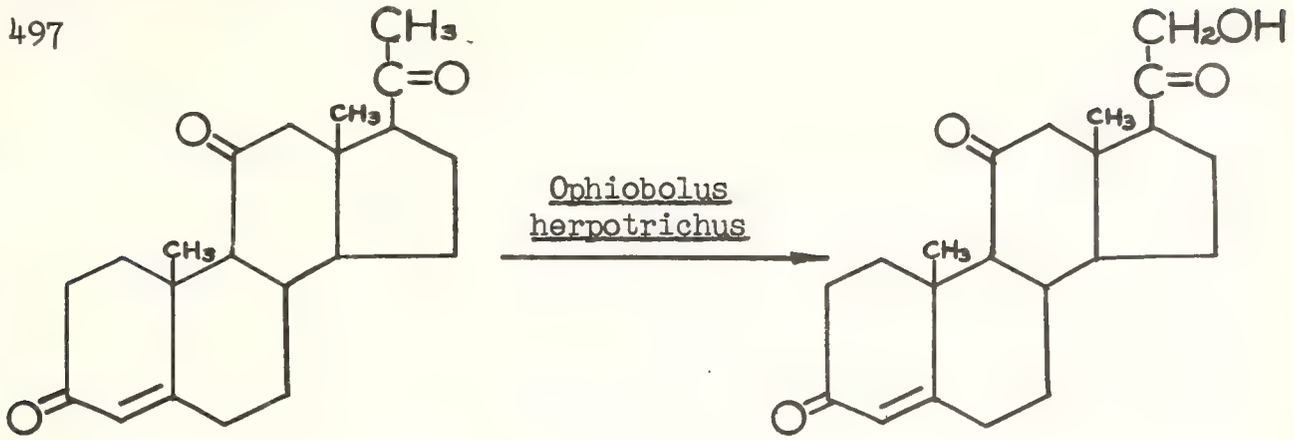


progesterone — corticosterone

Meystre et al., Helv. Chim. Acta 37, 1548-53 (1954).

C.A. 48, 13797d (1954).

Rx. 497

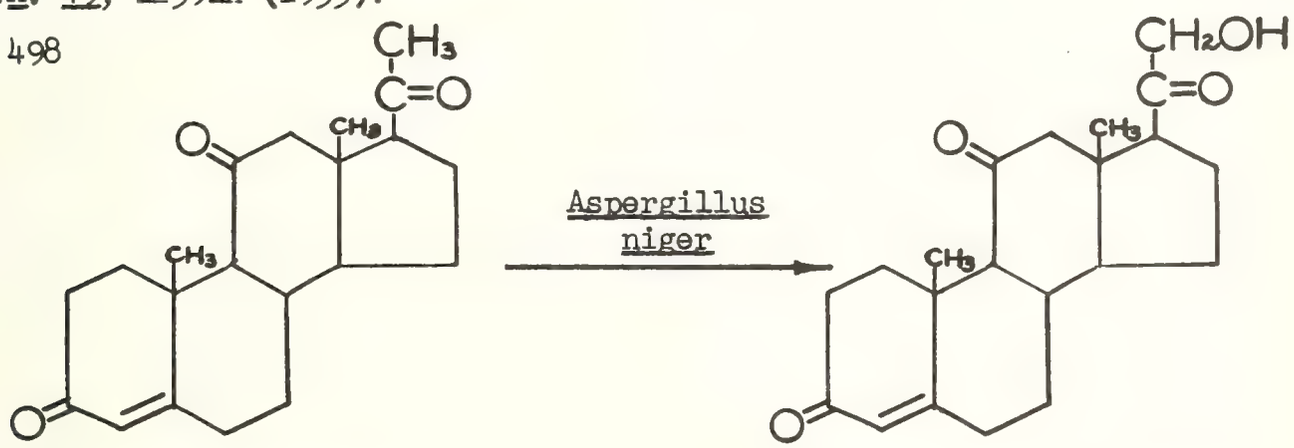


11-ketoprogesterone → 11-dehydrocorticosterone

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 498

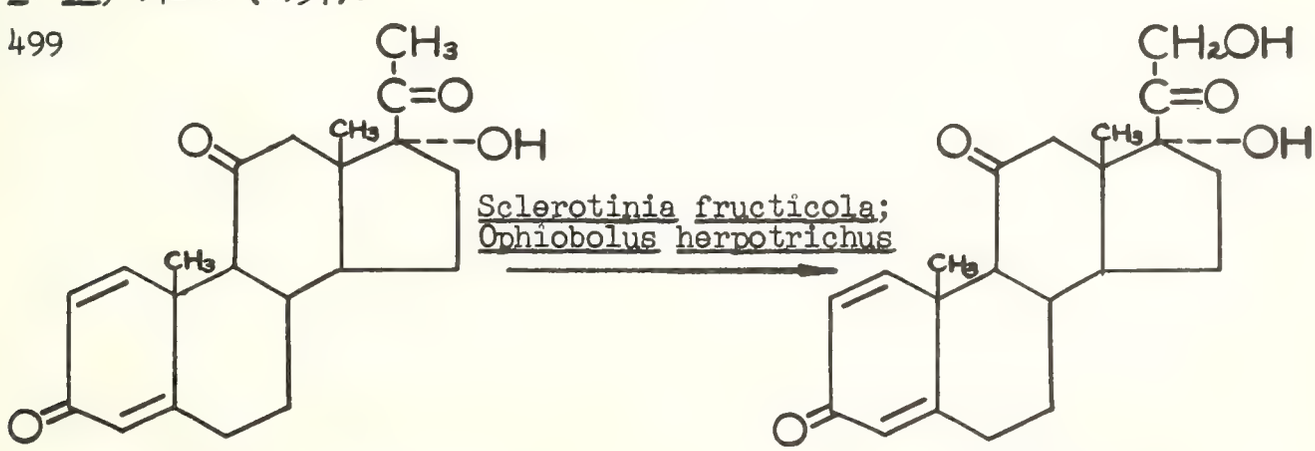


11-ketoprogesterone → 11-dehydrocorticosterone

Wettstein et al., U.S. 2,778,776 (Jan. 22, 1957).

C.A. 51, 9724a (1957).

Rx. 499

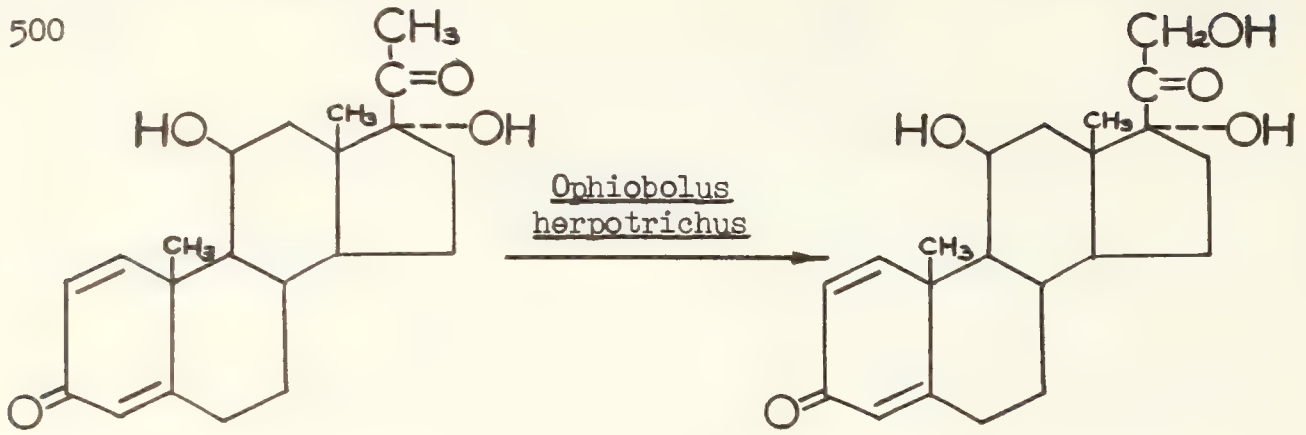


Δ^1-dehydro-11-keto-17α-hydroxy-progesterone → Δ^1-dehydrocortisone (prednisone)

Wettstein et al., U.S. 2,778,776 (Jan. 22, 1957).

C.A. 51, 9724a (1957).

Rx. 500



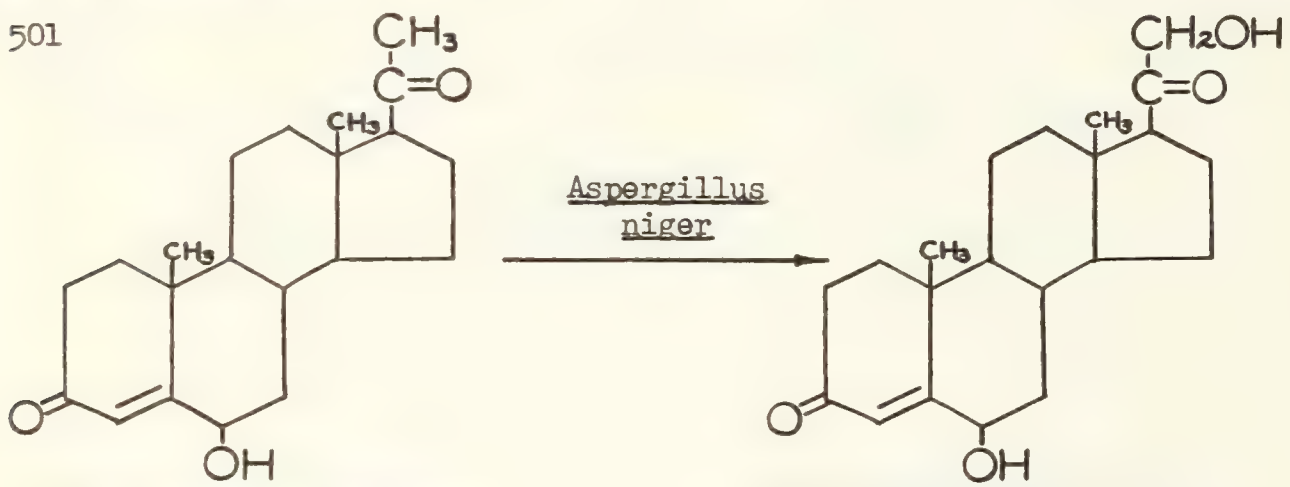
$\Delta^{1,4}$-pregnadiene-11β,17α-diol

$\Delta^{1,4}$-pregnadiene-11β,17α,21-triol (prednisolone)

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 501



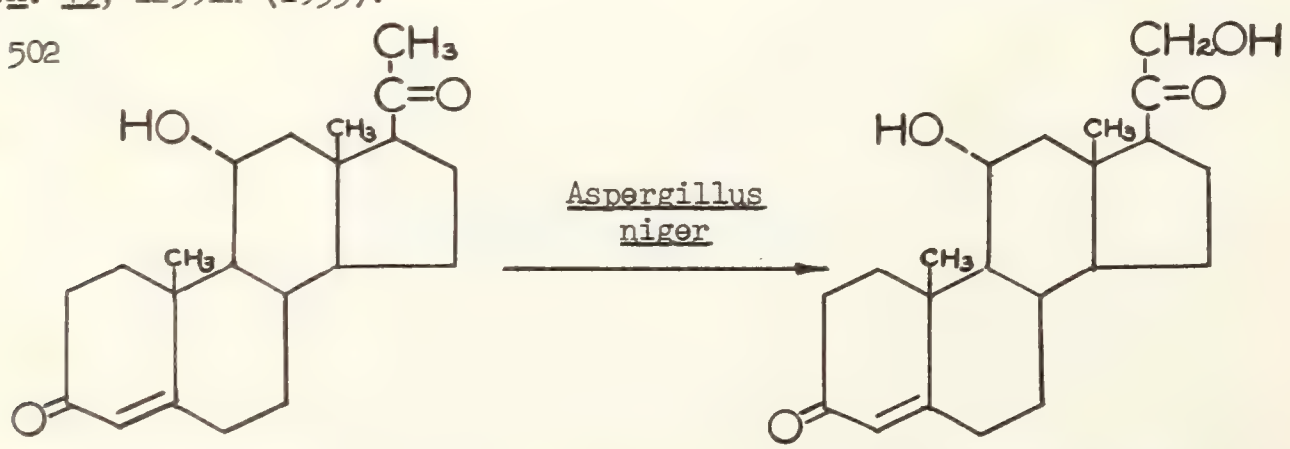
6β-hydroxyprogesterone

6β,21-dihydroxyprogesterone

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 502



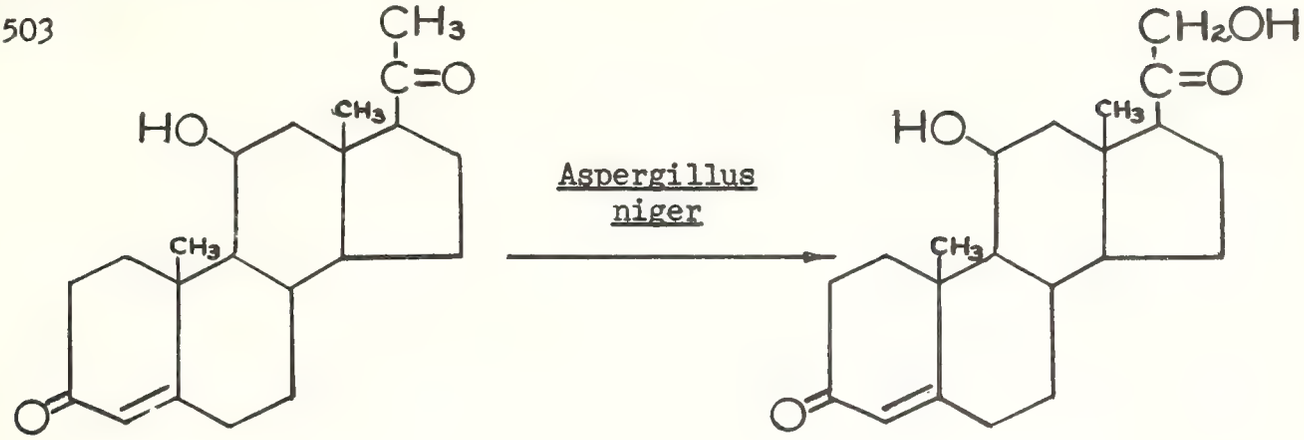
11α-hydroxyprogesterone

11α,21-dihydroxyprogesterone (11-epicorticosterone)

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 503

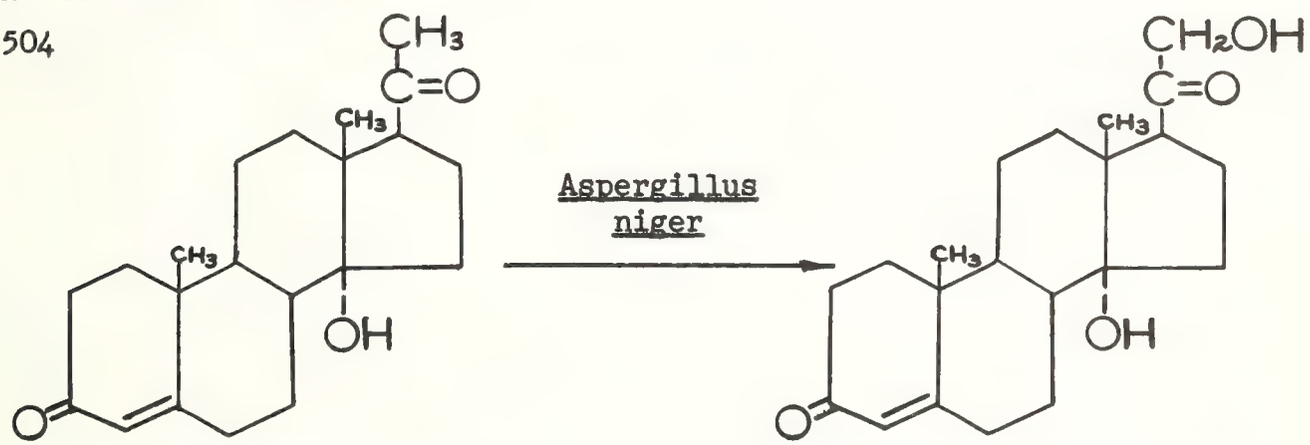


11β-hydroxyprogesterone — corticosterone

Zaffaroni et al., Experientia 11, 219 (1955).

C.A. 49, 12591h (1955).

Rx. 504

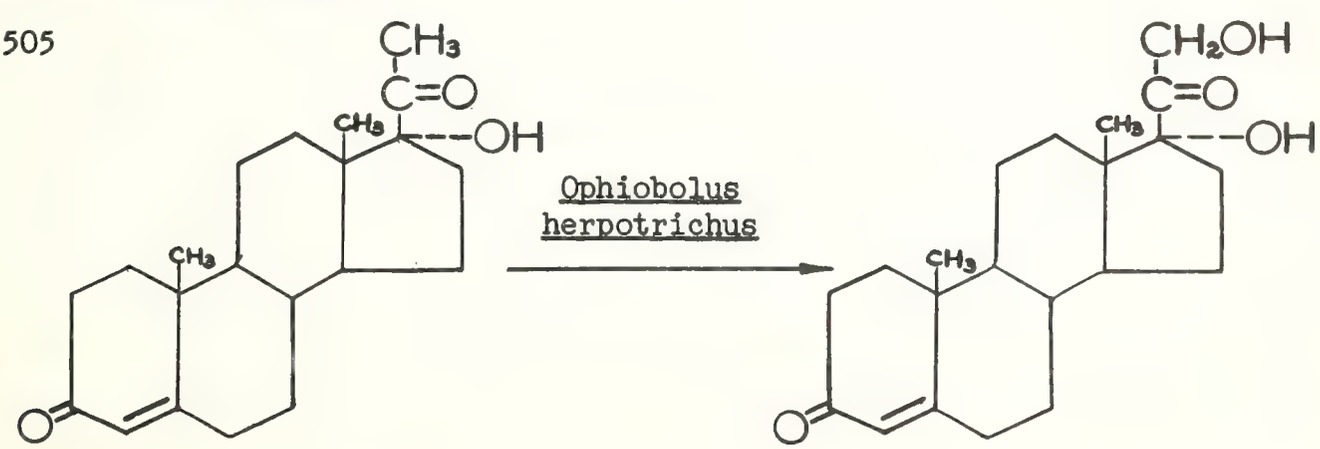


14α-hydroxyprogesterone — 14α,21-dihydroxyprogesterone

Meystre et al., Helv. Chim. Acta 37, 1548-53 (1954).

C.A. 48, 13797d (1954).

Rx. 505

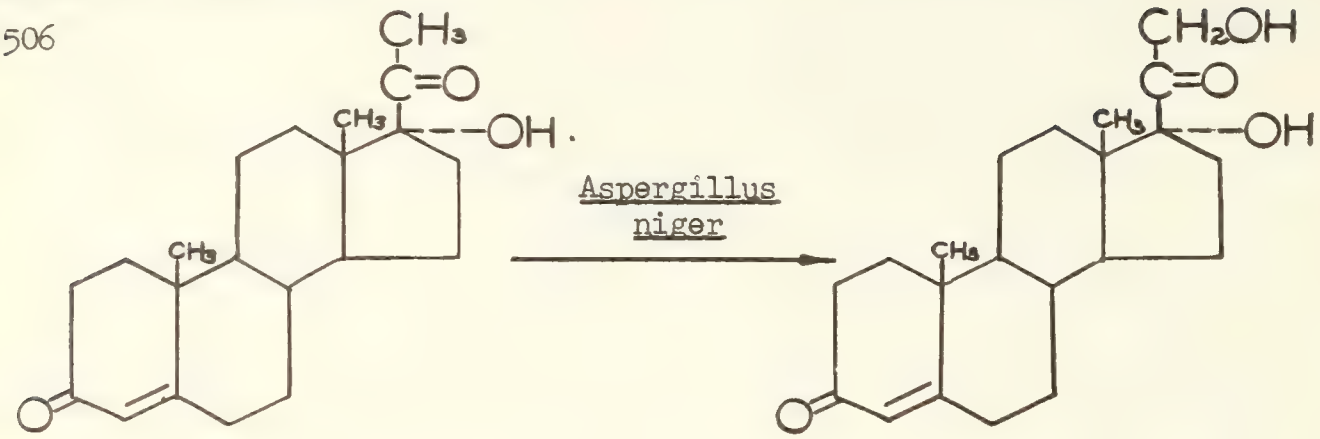


17α-hydroxyprogesterone — 17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd. S)

Syntex, S. A., Brit. 749,943 (June 6, 1956).

C.A. 51, 2084b (1957).

Rx. 506



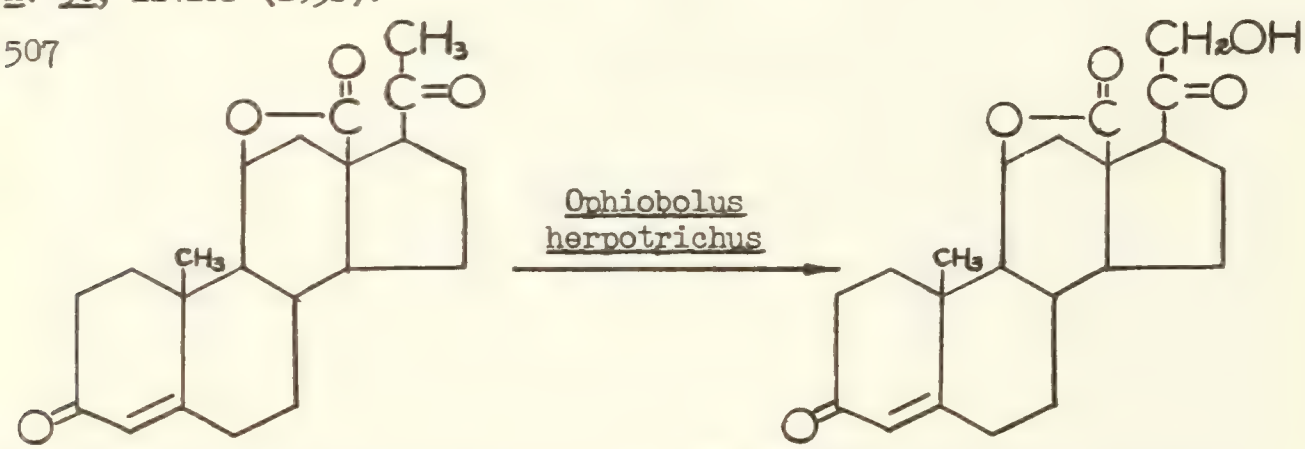
17α-hydroxyprogesterone

17α-hydroxy-11-desoxy-corticosterone (18%)

Vischer et al., Experientia 12, 50-2 (1956).

C.A. 50, 11418f (1956).

Rx. 507

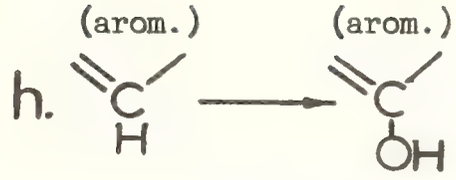


γ-(11,18)lactone of d,l-11β-hydroxy-Δ^4-pregnene-3,20-dione-18-carboxylic acid

γ-(11,18)lactone of d-11β,21-dihydroxy-Δ^4-pregnene-3,20-dione-18-carboxylic acid

---

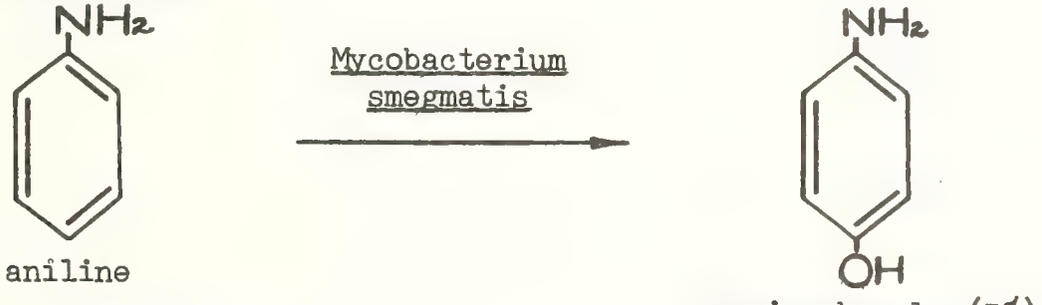
I. Oxidation



Sloane et al., J. Biol. Chem. 193, 453-8 (1951).

C.A. 46, 2623f (1952).

Rx. 508



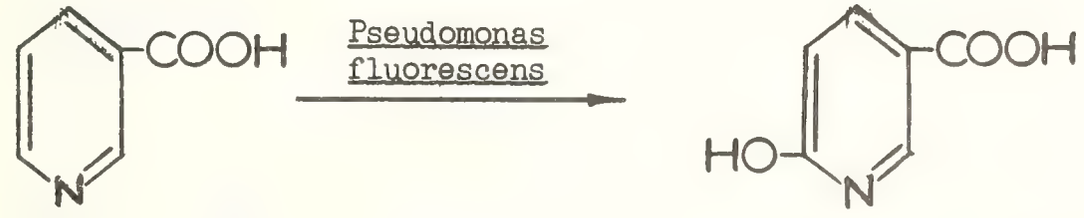
aniline

p-aminophenol (5%)

Hughes, Biochim. et Biophys. Acta 9, 226-7 (1952).

C.A. 47, 2832h (1953).

Rx. 509



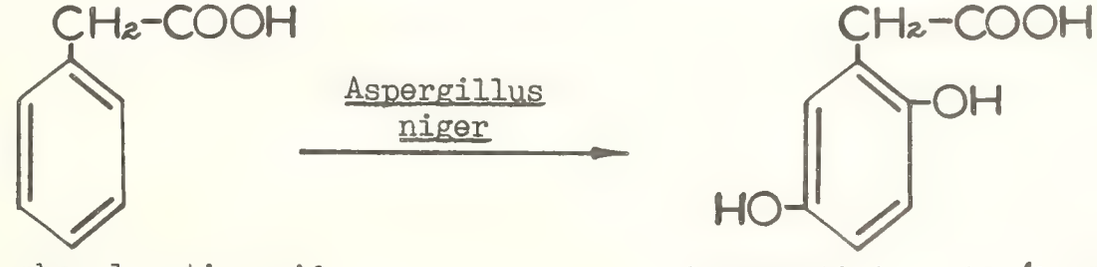
nicotinic acid

6-hydroxynicotinic acid

Kluyver and van Zijp, Antonie van Leeuwenhoek J. Microbiol. Serol. 17, 315-24 (1951).

C.A. 46, 5125b (1952).

Rx. 510

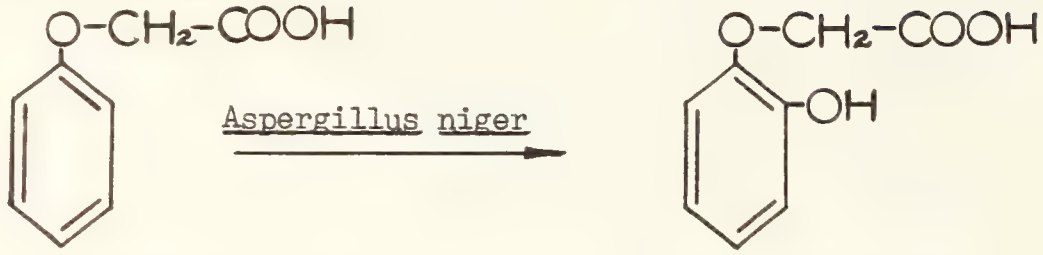


phenylacetic acid

homogentisic acid (15.7%)

Byrde and Woodcock, Biochem. J. 65, 682-6 (1957).
C.A. 51, 8874e (1957).

Rx. 511

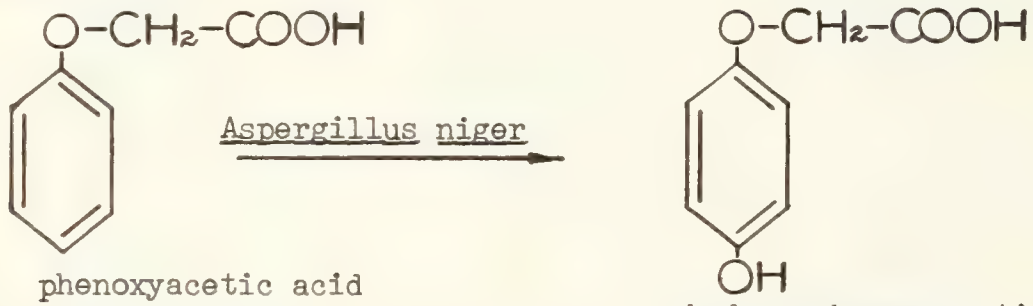


phenoxyacetic acid

o-hydroxyphenoxyacetic acid (8.3%)

Byrde and Woodcock, Biochem. J. 65, 682-6 (1957).
C.A. 51, 8874e (1957).

Rx. 512

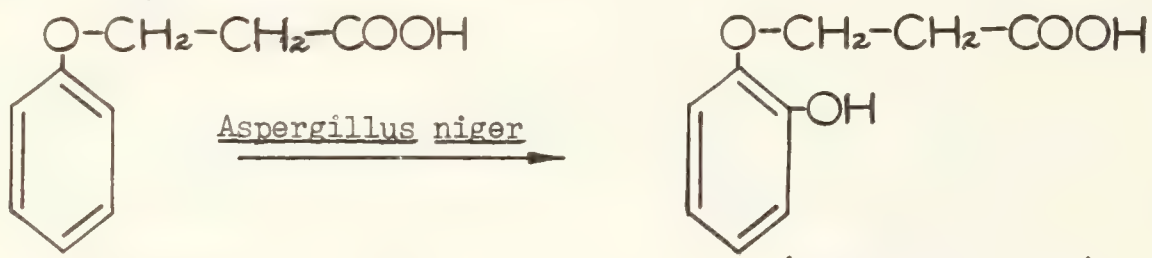


phenoxyacetic acid

p-hydroxyphenoxyacetic acid (37%)

Byrde and Woodcock, Biochem. J. 65, 682-6 (1957).
C.A. 51, 8874e (1957).

Rx. 513

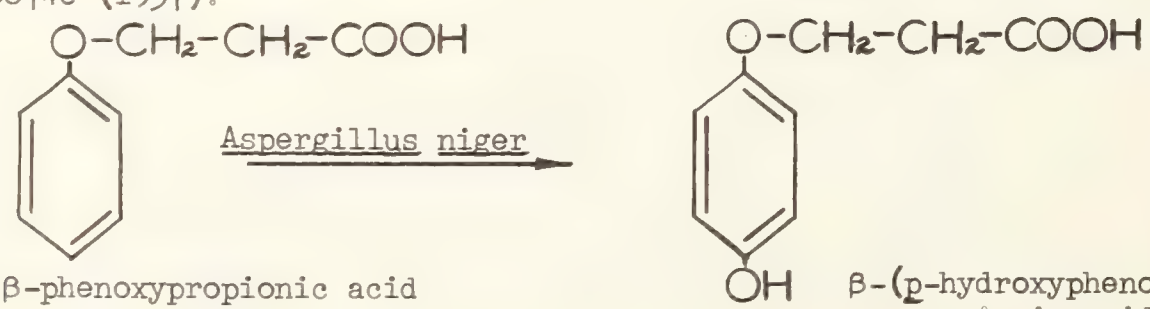


β-phenoxypropionic acid

β-(o-hydroxyphenoxy)-propionic acid

Byrde and Woodcock, Biochem. J. 65, 682-6 (1957).
C.A. 51, 8874e (1957).

Rx. 514



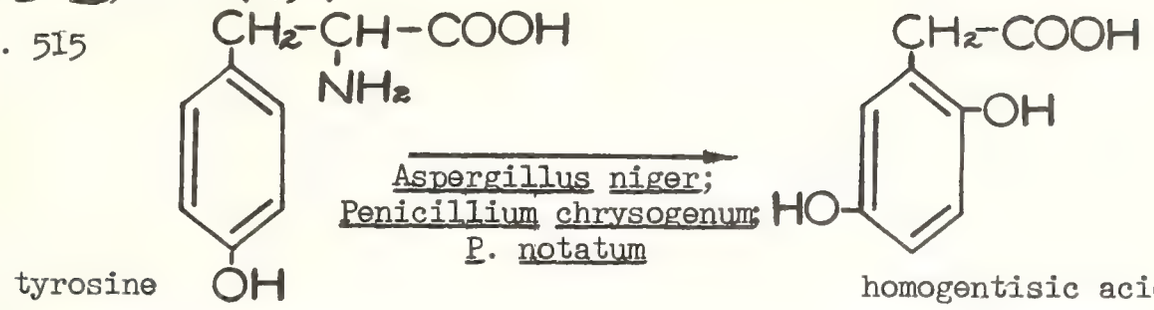
β-phenoxypropionic acid

β-(p-hydroxyphenoxy)-propionic acid

Utkin, Biokhimiya 15, 330-3 (1950).

C.A. 45, 216c (1951).

Rx. 515



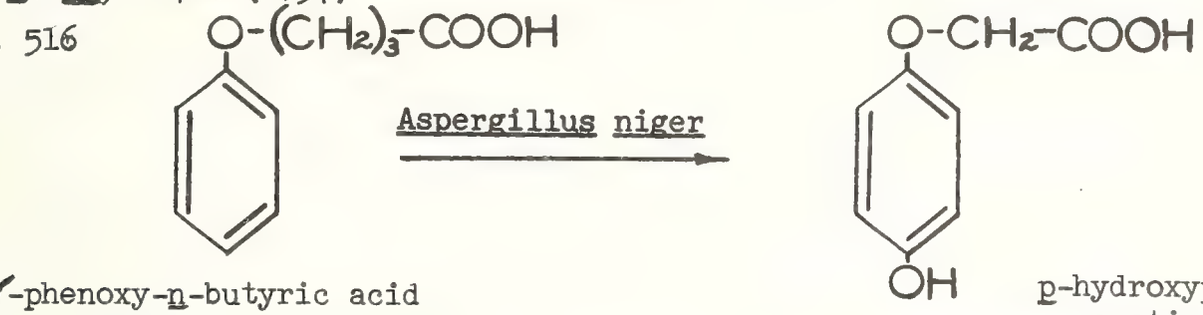
tyrosine

homogentisic acid

Byrde and Woodcock, Biochem. J. 65, 682-6 (1957).

C.A. 51, 8874e (1957).

Rx. 516



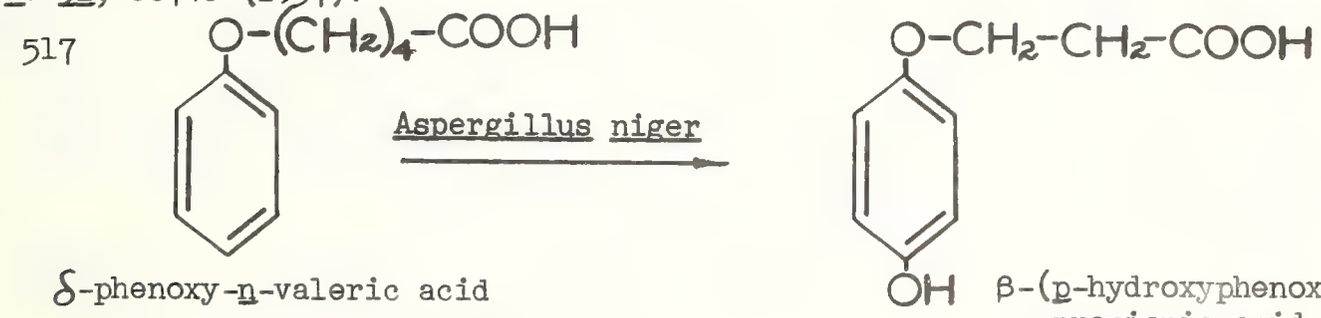
γ-phenoxy-n-butyric acid

p-hydroxyphenoxy-acetic acid

Byrde and Woodcock, Biochem. J. 65, 682-6 (1957).

C.A. 51, 8874e (1957).

Rx. 517



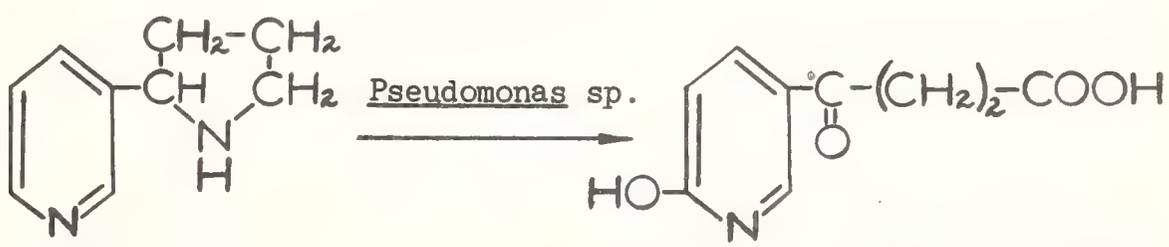
δ-phenoxy-n-valeric acid

β-(p-hydroxyphenoxy) propionic acid

Wada, Arch. Biochem. Biophys. 64, 244-6 (1956).

C.A. 51, 553e (1957).

Rx. 518



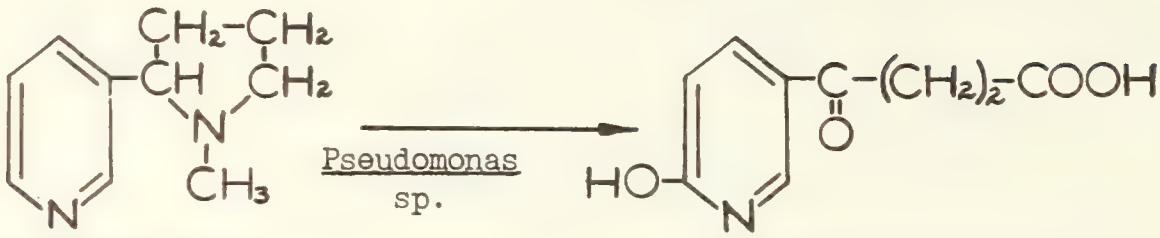
nornicotine

3-succinoyl-6-hydroxypyridine (approx. 38%)

Wada, Arch. Biochem. Biophys. 64, 244-6 (1956).

C.A. 51, 553e (1957).

Rx. 519



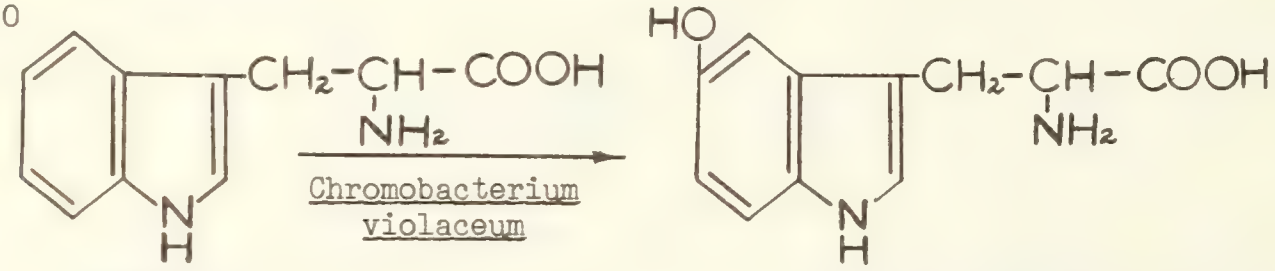
nicotine

3-succinoyl-6-hydroxy-pyridine (12.5%)

Mitoma et al., Nature 175, 994-5 (1955). See ibid., Arch. Biochem. Biophys. 63, 122-30 (1956).

C.A. 49, 14106d (1955).

Rx. 520



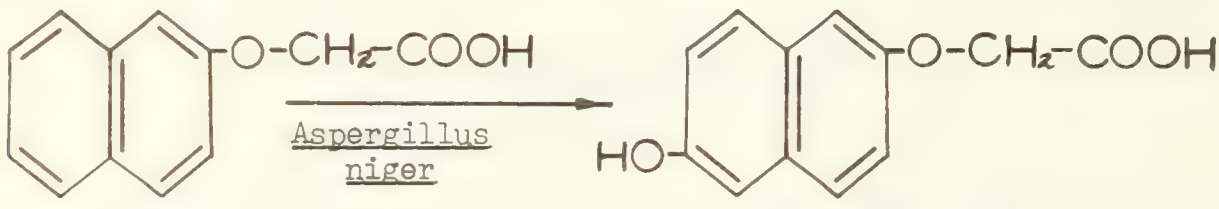
tryptophane

5-hydroxytryptophane

Byrde et al., Biochem. J. 64, 154-60 (1956).

C.A. 50, 16955g (1956).

Rx. 521



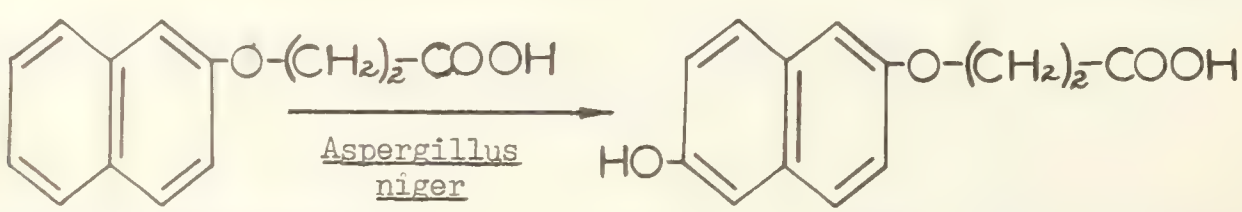
2-naphthyloxyacetic acid

6-hydroxy-2-naphthyloxyacetic acid

Byrde et al., Biochem. J. 64, 154-60 (1956).

C.A. 50, 16955g (1956).

Rx. 522



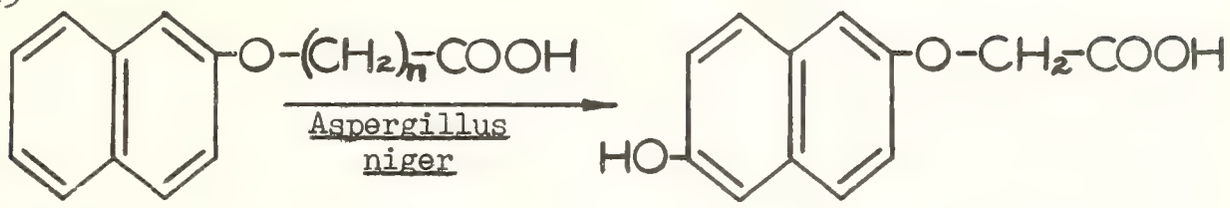
β-(2-naphthyloxy)-propionic acid

β-(6-hydroxy-2-naphthyloxy)-propionic acid

Byrde et al., Biochem. J. 64, 154-60 (1956).

C.A. 50, 16955g (1956).

Rx. 523



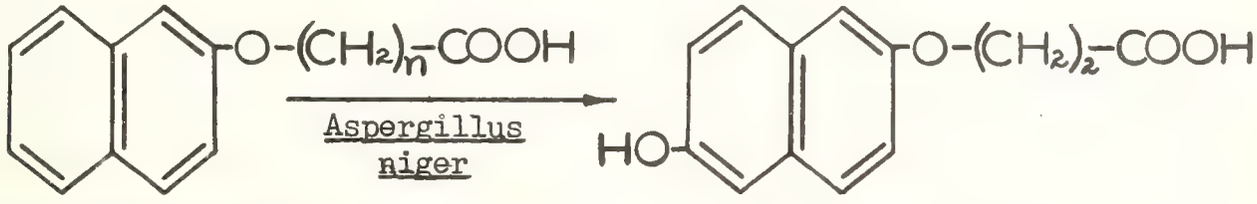
ω-(2-naphthyloxy)-alkanoic acid (where n = 3,5,7 or 9)

6-hydroxy-2-naphthyloxyacetic acid

Byrde et al., Biochem. J. 64, 154-60 (1956).

C.A. 50, 16955g (1956).

Rx. 524



ω-(2-naphthyloxy)-alkanoic acid (where n = 4,6 or 8)

β-(6-hydroxy-2-naphthyloxy)-propionic acid

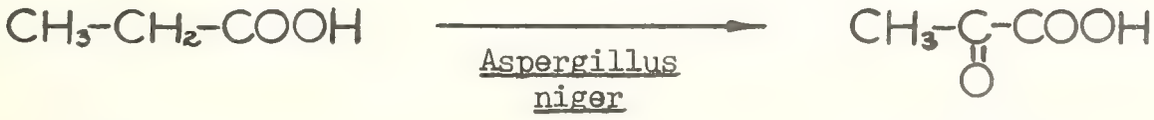
---

i. $-CH_2- \longrightarrow -\overset{\overset{O}{\|}}{C}-$

Walker and Coppock, J. Chem. Soc., 803-9 (1928).

C.A. 22, 2394[9] (1928).

Rx. 525



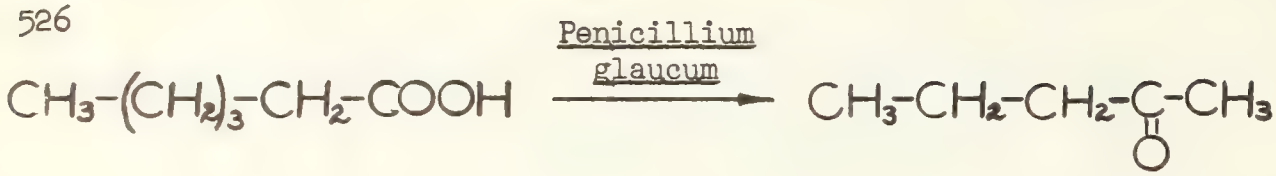
propionic acid

pyruvic acid

Stärkle, Biochem. Z. 151, 371-412 (1924).

C.A. 19, 2244[8] (1925).

Rx. 526

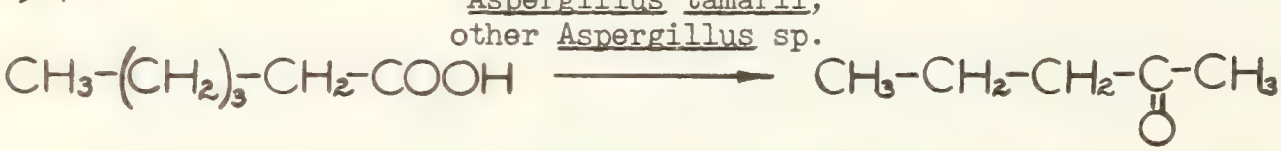


caproic acid (ammonium salt) — methyl-n-propyl ketone

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 527

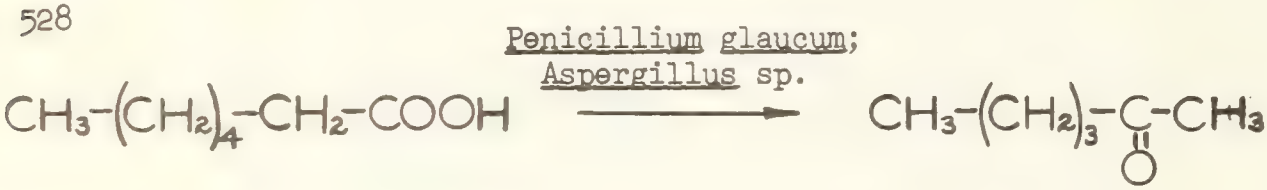


caproic acid — methyl-n-propyl ketone

Stärkle, Biochem. Z. 151, 371-412 (1924).

C.A. 19, 2244[8] (1925).

Rx. 528

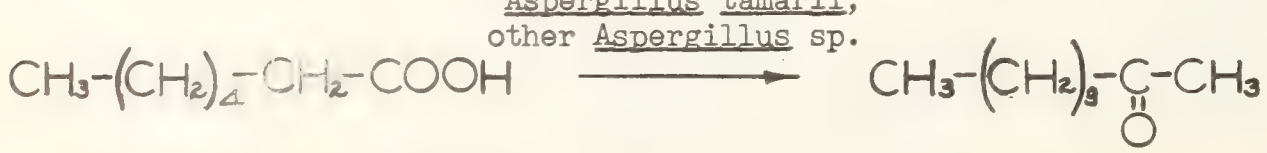


oenanthic acid (from fat) — methyl-n-butyl ketone

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 529

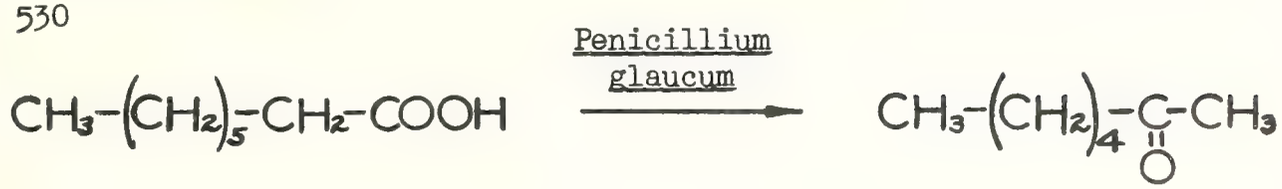


oenanthic acid — methyl-n-butyl ketone

Stärkle, Biochem. Z. 151, 371-412 (1924).

C.A. 19, 2244[8] (1925).

Rx. 530

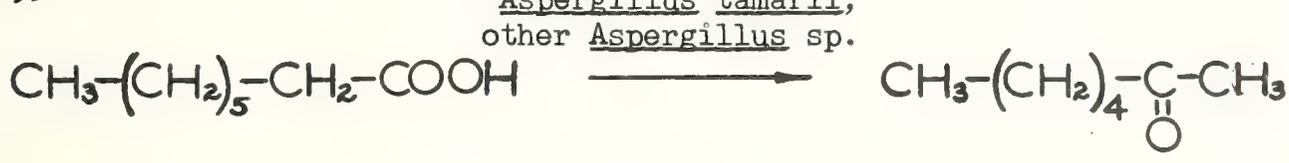


caprylic acid (ammonium salt) — methyl-n-amyl ketone

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 531

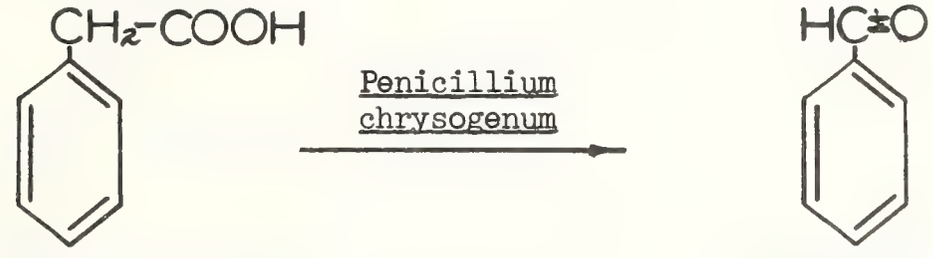


caprylic acid — methyl-n-amyl ketone

Hockenhull et al., Biochem. J. 50, 605-9 (1952).

C.A. 46, 5129d (1952).

Rx. 532

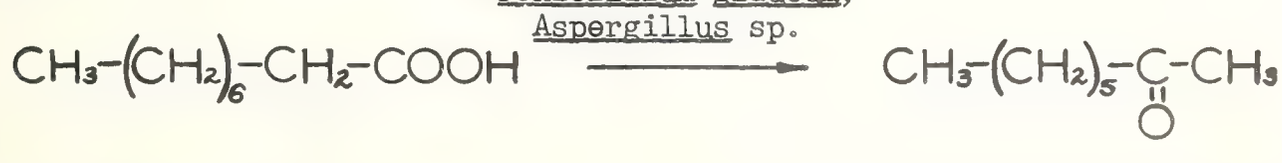


phenylacetic acid — benzaldehyde

Stärkle, Biochem. Z. 151, 371-412 (1924).

C.A. 19, 2244[8] (1925).

Rx. 533

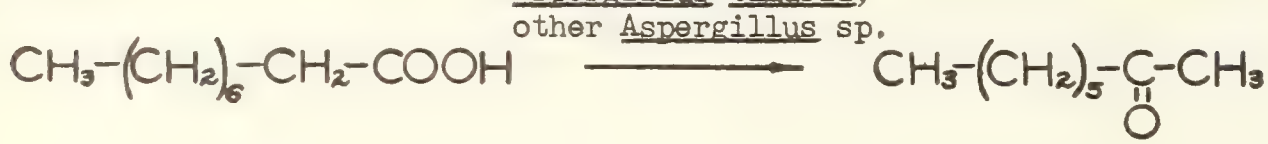


pelargonic acid (from fat) — methyl-n-hexyl ketone

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 534

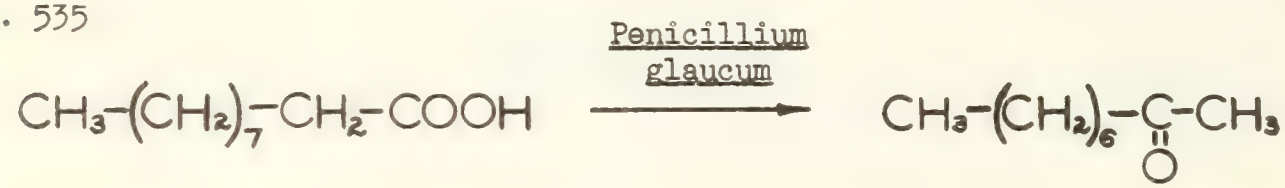


pelargonic acid — methyl-n-hexyl ketone

Stärkle, Biochem. Z. 151, 371-412 (1924).

C.A. 19, 2244[8] (1925).

Rx. 535

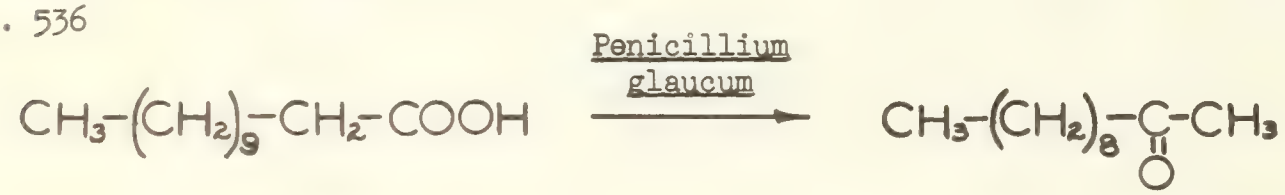


capric acid (ammonium salt) — methyl-n-heptyl ketone

Stärkle, Biochem. Z. 151, 371-412 (1924).

C.A. 19, 2244[8] (1925).

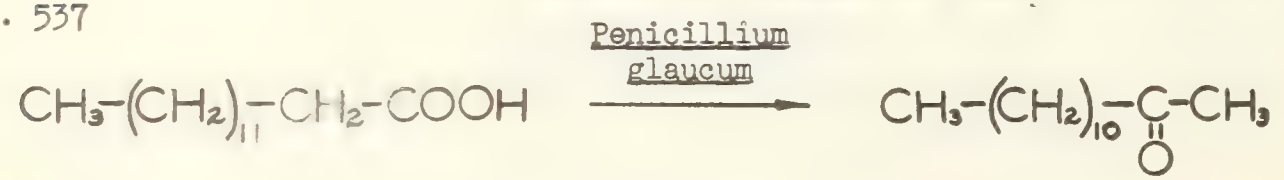
Rx. 536



lauric acid (from trilaurin) — methyl-n-nonyl ketone

Karrer, "Organic Chemistry," 4th Engl. ed., Elsevier Publishing Co., Inc. New York, N.Y. 1950. p. 217ff.
See Acklin, Biochem. Z. 204, 253-74 (1929).

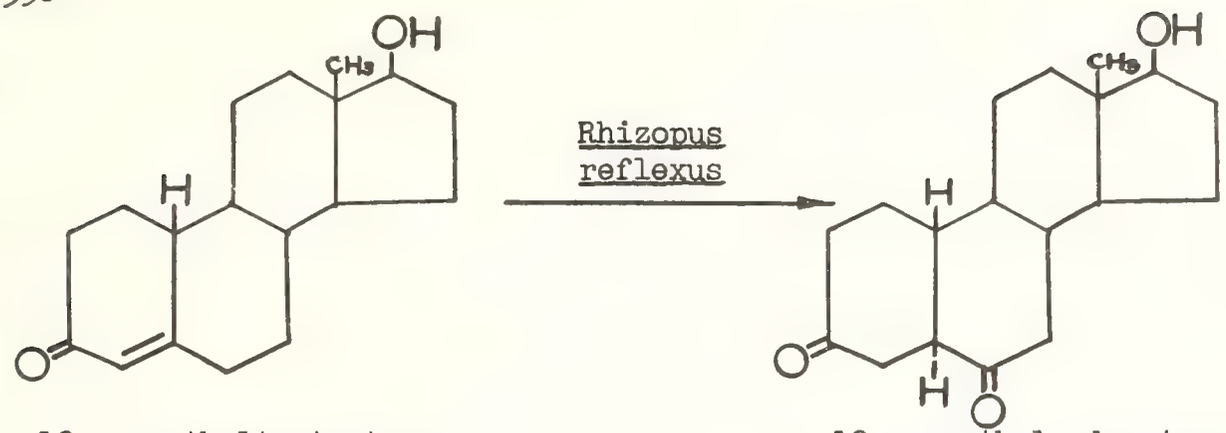
Rx. 537



myristic acid — methyl-n-undecyl ketone

Murray and Peterson, U.S. 2,692,273 (Oct. 19, 1954).
C.A. 49, 11732b (1955)

Rx. 538

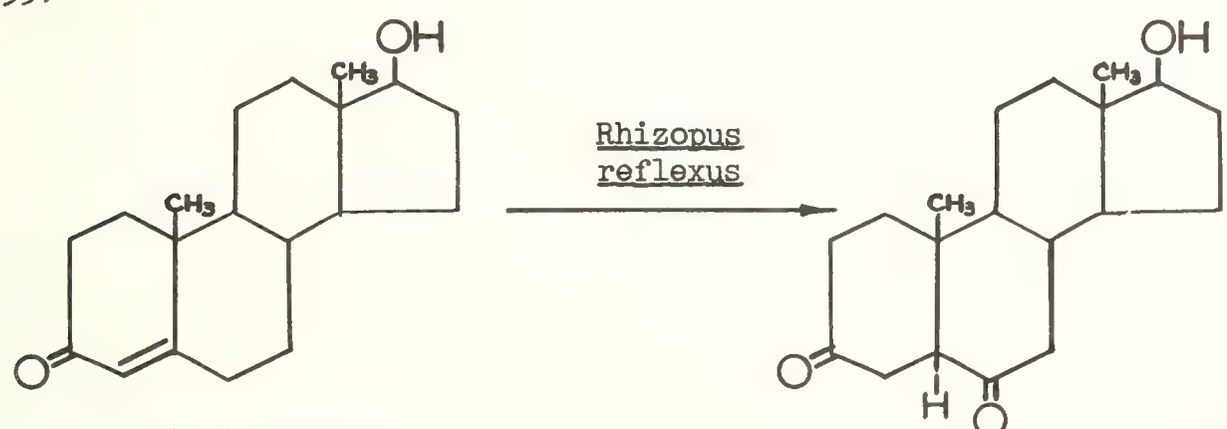


10-normethyltestosterone

10-normethylandrostane-17β-ol-3,6-dione

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954). See U.S. 2,692,273 (Oct. 19, 1954).
C.A. 49, 9021i (1955).

Rx. 539

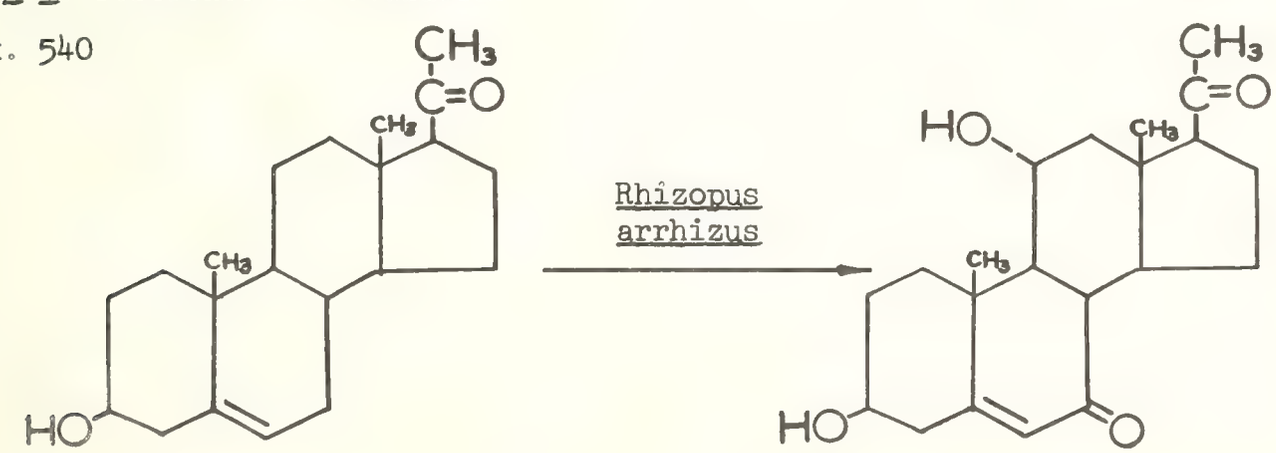


testosterone

androstane-17β-ol-3,6-dione

Murray and Peterson, Can. 506,689 (Oct. 19, 1954). See U.S. 2,703,326 (Mar. 1, 1955).
C.A. reference not available

Rx. 540



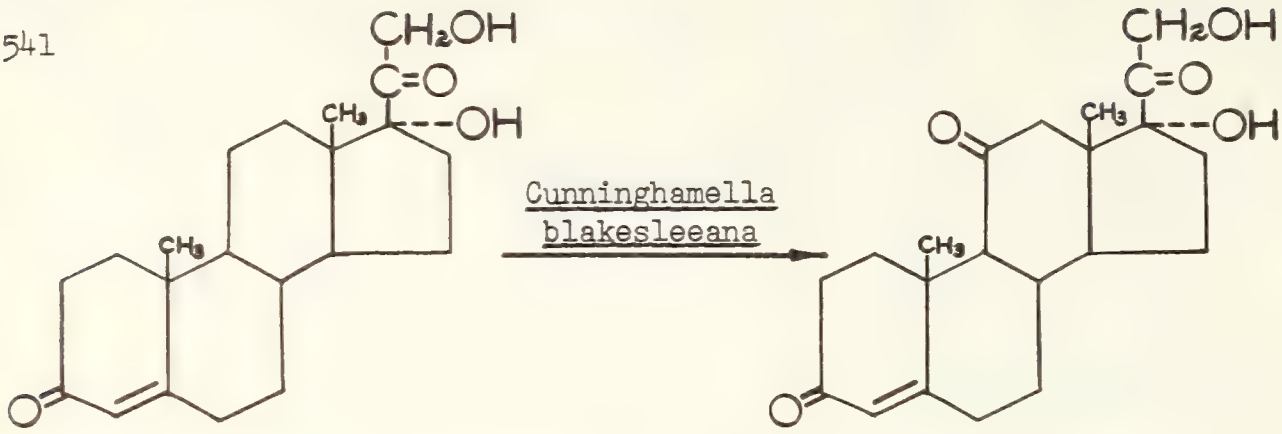
Δ^5-pregnene-3β-ol-20-one

Δ^5-pregnene-3β,11α-diol-7,20-dione (17.5%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 541



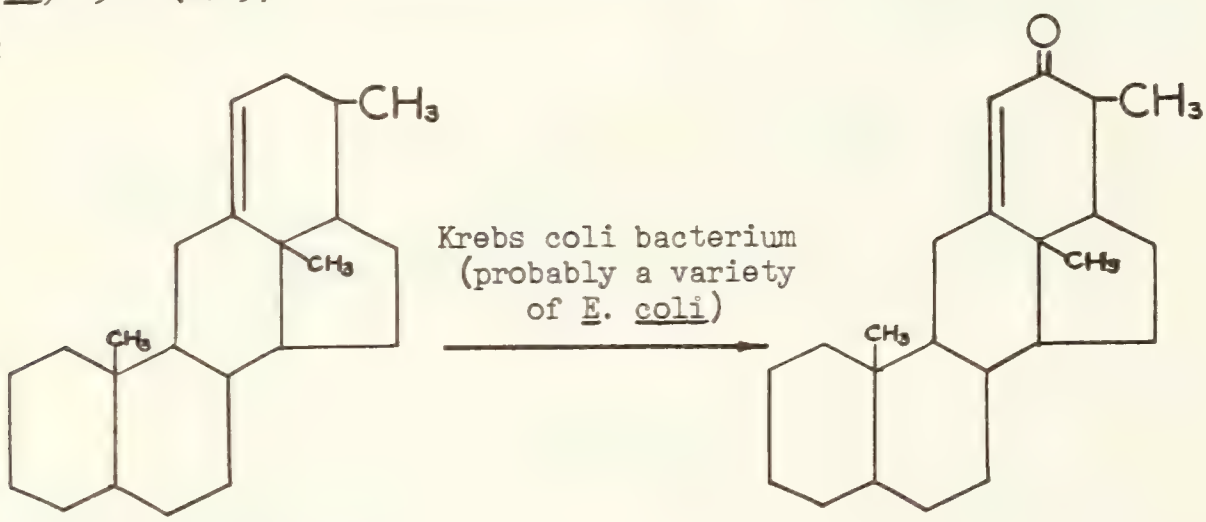
17α-hydroxy-11-desoxycorticosterone

cortisone
(9.5-13.0%)

Butenandt and Dannenberg, Naturwissenschaften 30, 52 (1942).

C.A. 37, 1529 (1943).

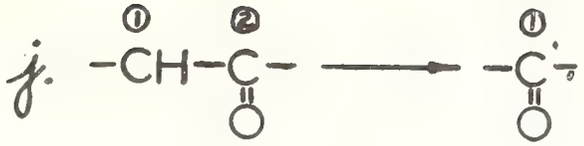
Rx. 542



10,13,20-trimethylhexadeca-
hydrocholanthrene
(dehydronorcholene)

22-ketodehydronorcholene
(15-18%)

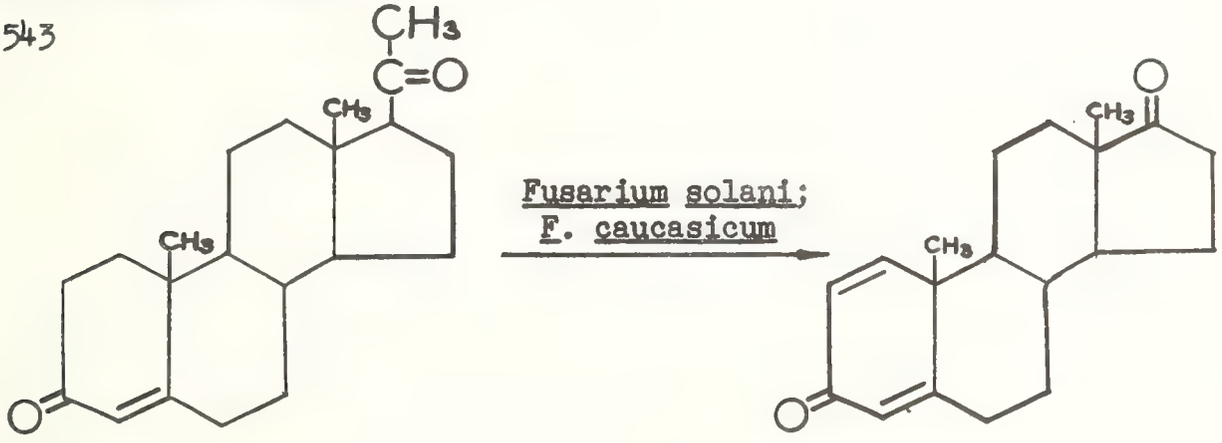
I. Oxidation



Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 543



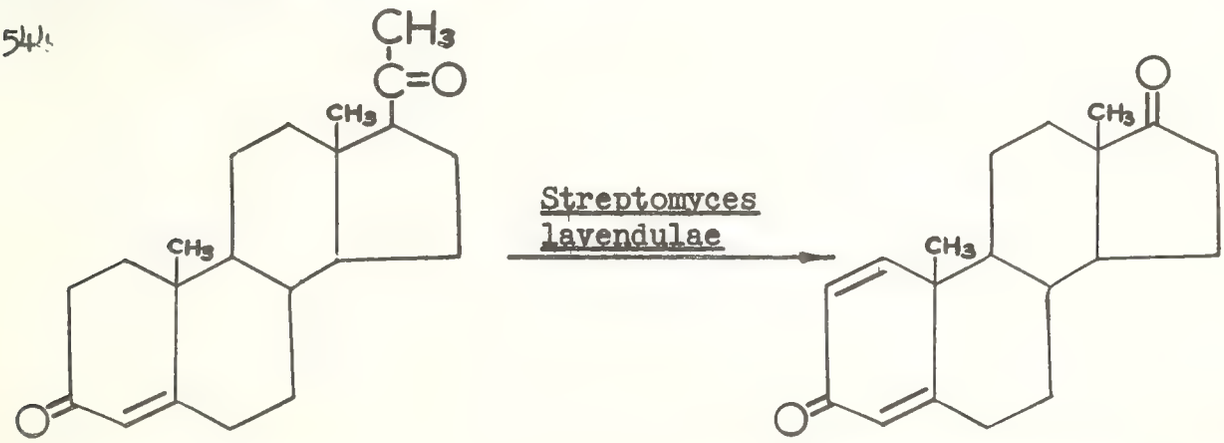
progesterone

$\Delta^{1,4}$-androstadiene-3,17-dione

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 544

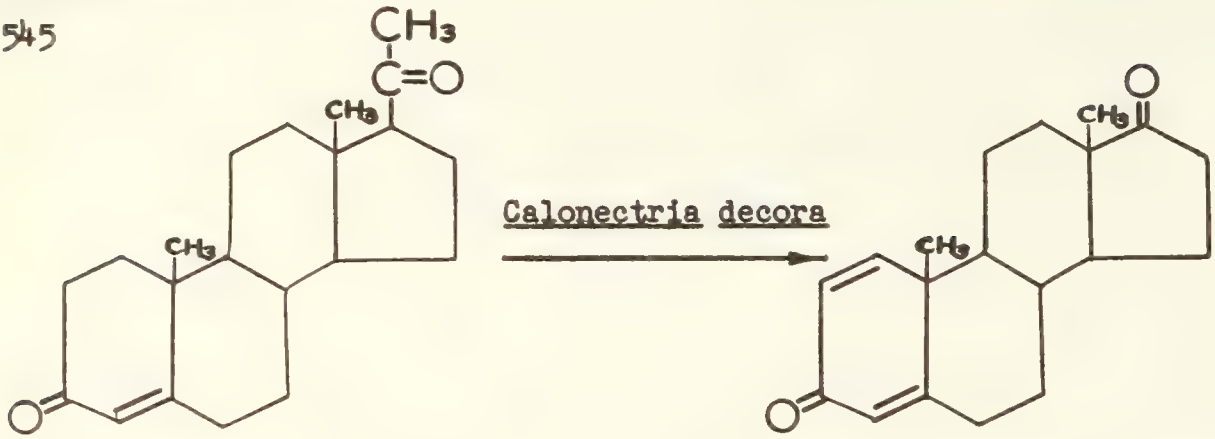


progesterone

$\Delta^{1,4}$-androstadiene-3,17-dione (7%)

Vischer et al., Helv. Chim. Acta 38, 835-40 (1955).
C.A. 50, 12093b (1956).

Rx. 545

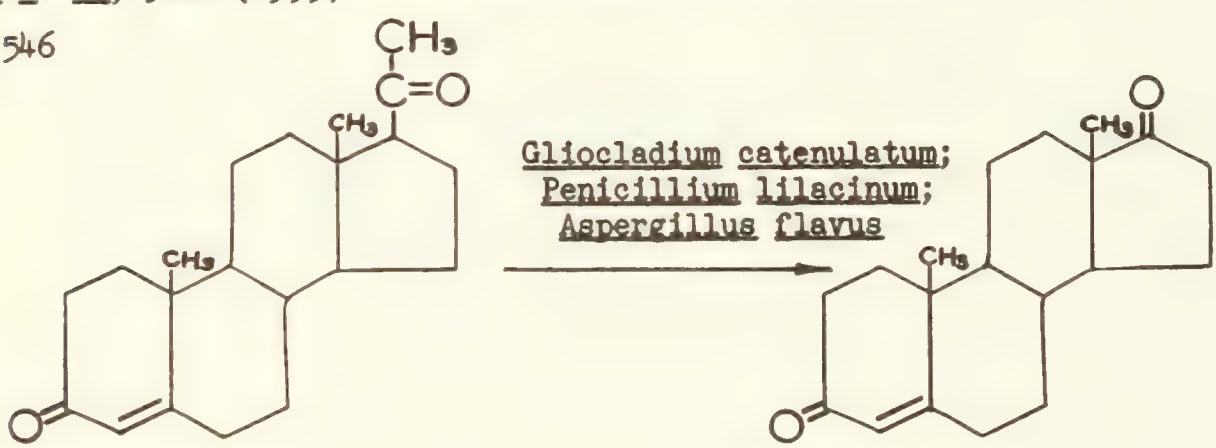


progesterone

$\Delta^{1,4}$-androstadiene-3,17-dione

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953).
C.A. 49, 366a (1955).

Rx. 546

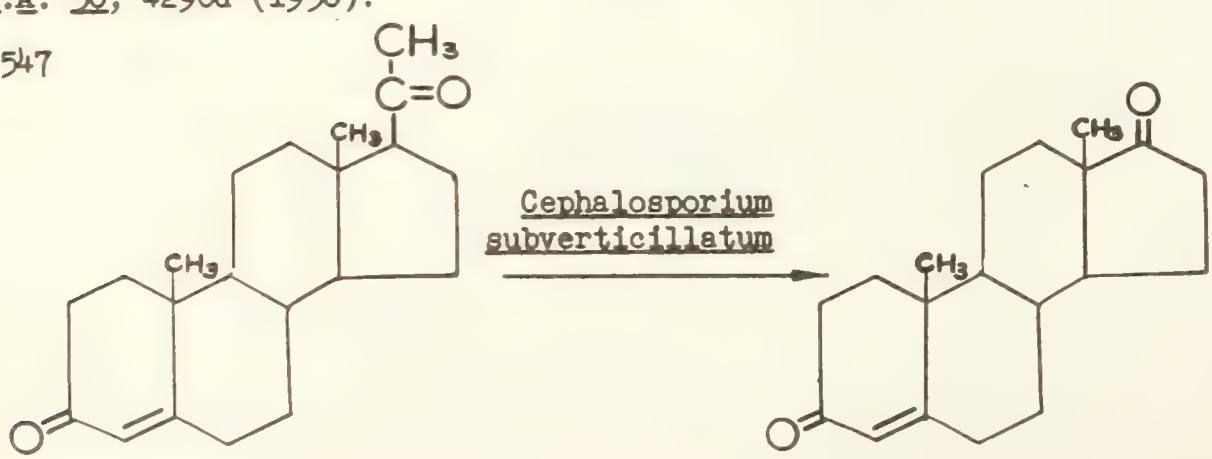


progesterone

Δ^{4}-androstene-3,17-dione

Bodánszky et al., Experientia 11, 384 (1955).
C.A. 50, 4290d (1956).

Rx. 547



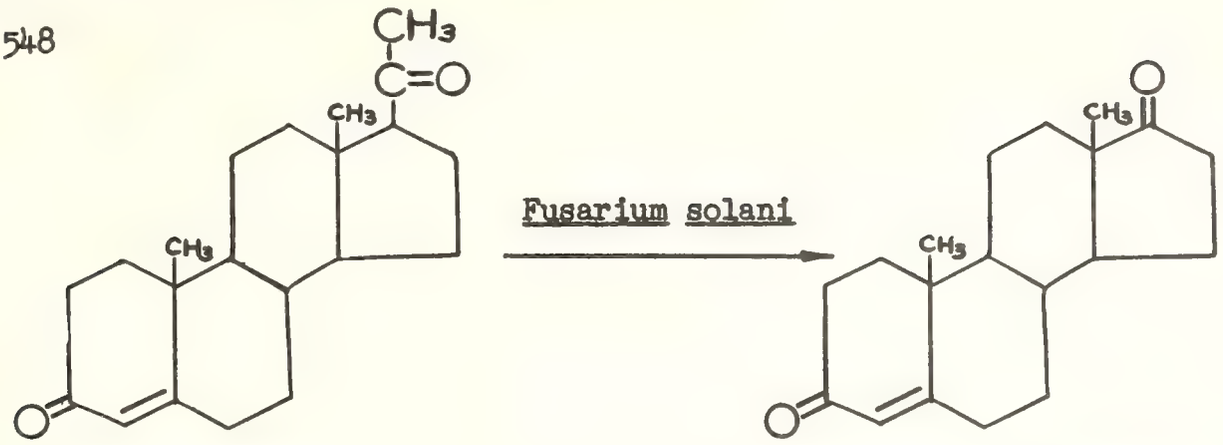
progesterone

Δ^{4}-androstene-3,17-dione
(approx. 40%)

Szpilfogel et al., Rec. trav. chim. 75, 402-4 (1956).

C.A. 50, 13162a (1956).

Rx. 548



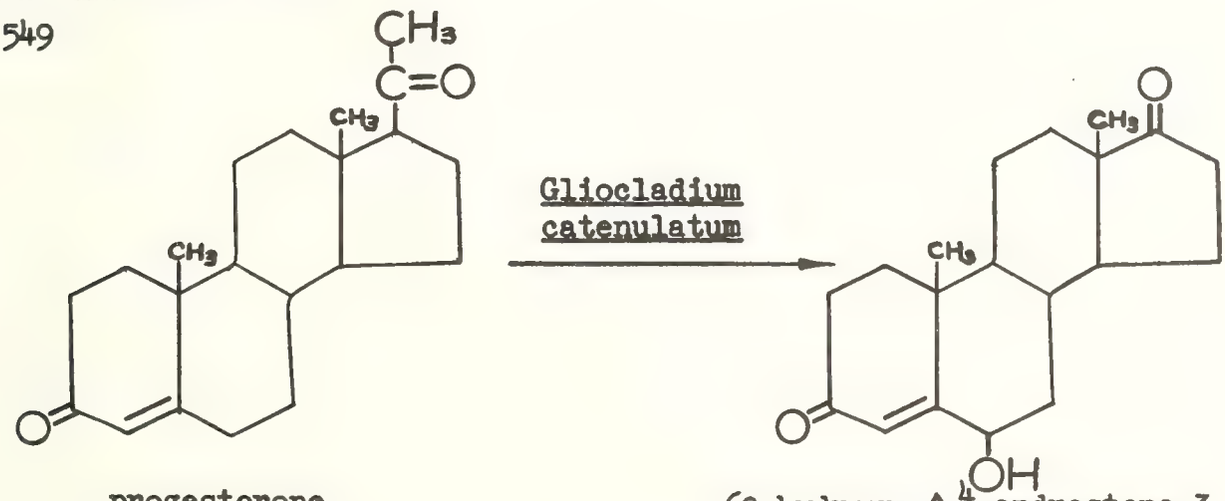
progesterone

Δ^4-androstene-3,17-dione

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953).

C.A. 49, 366a (1955).

Rx. 549



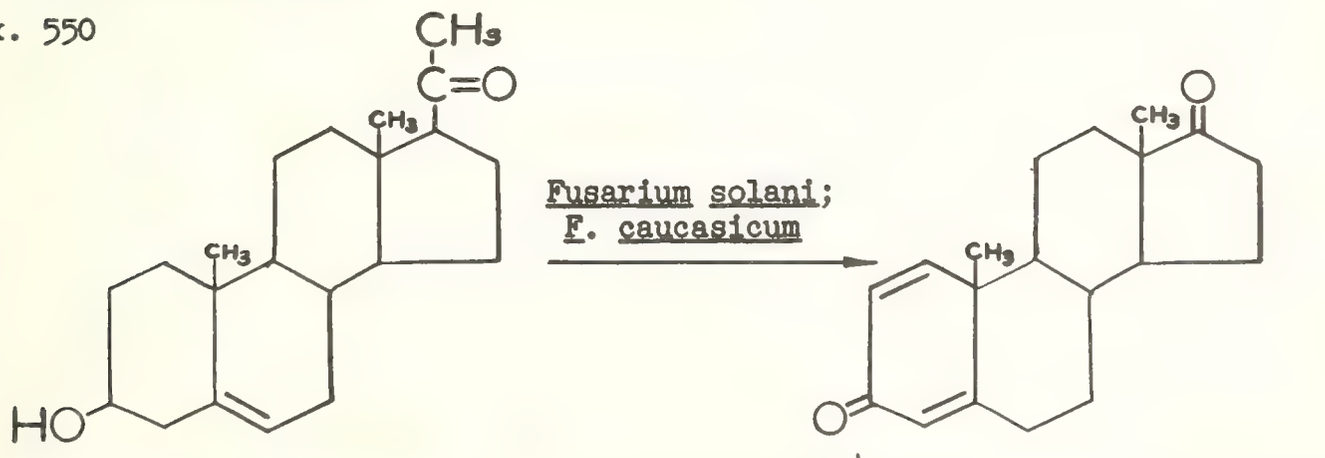
progesterone

6β-hydroxy-Δ^4-androstene-3, 17-dione

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 550



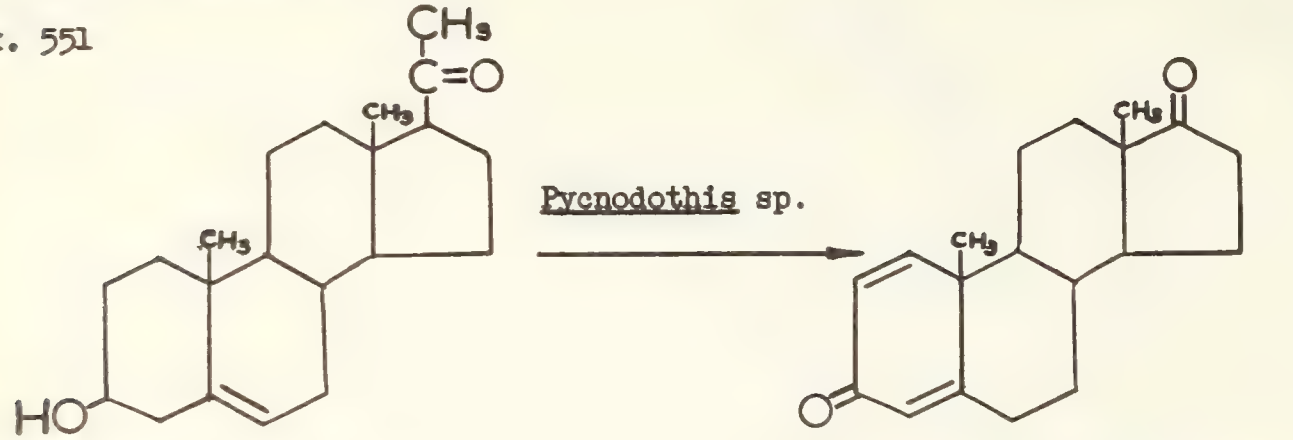
Δ^5-pregnene-3β-ol-20-one

$\Delta^{1,4}$-androstadiene-3,17-dione

Kita and Shull, in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 551



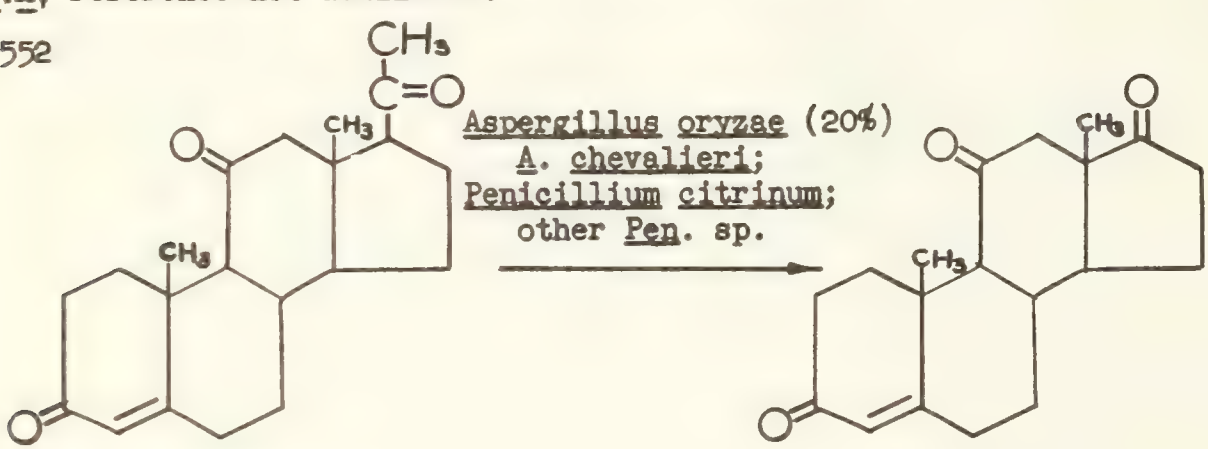
Δ^5-pregnene-3β-ol-20-one

$\Delta^{1,4}$-androstadiene-3,17-dione

Čapek et al., Naturwissenschaften 43, 471 (1956).

C.A, reference not available.

Rx. 552



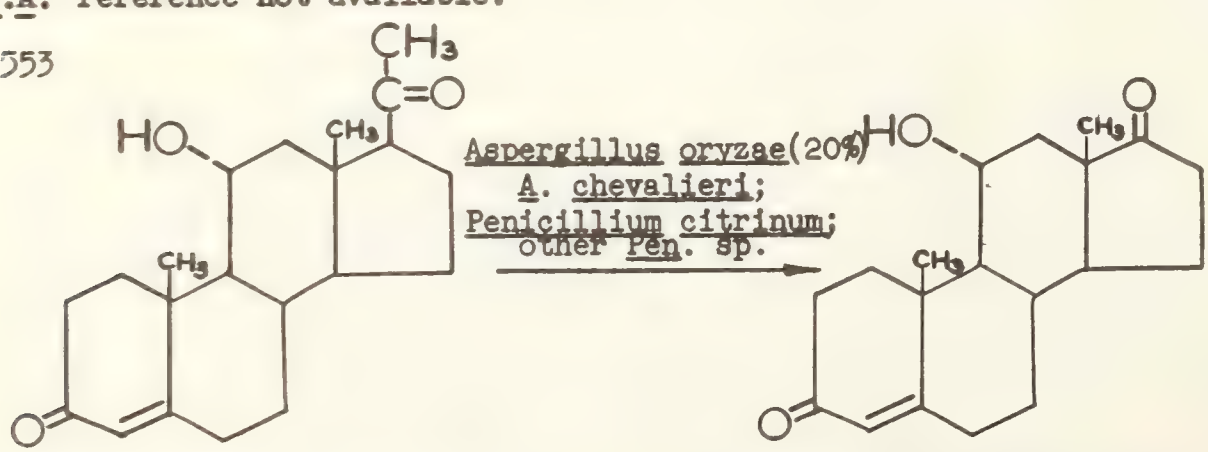
11-ketoprogesterone

adrenosterone

Čapek et al., Naturwissenschaften 43, 471 (1956).

C.A. reference not available.

Rx. 553



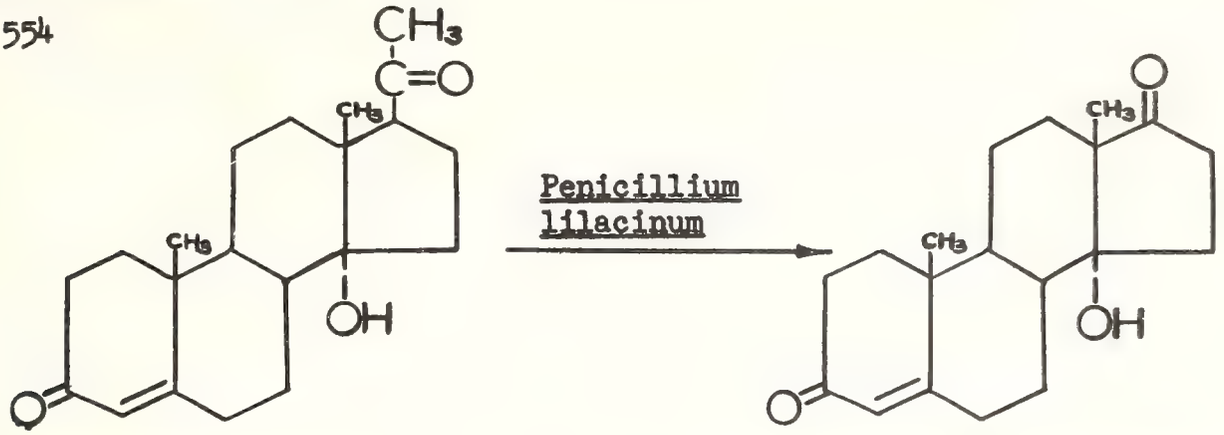
11α-hydroxyprogesterone

11α-hydroxy-Δ^4-androstene-3, 17-dione

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953). (Footnote 6)

C.A. 49, 366a (1955).

Rx. 554



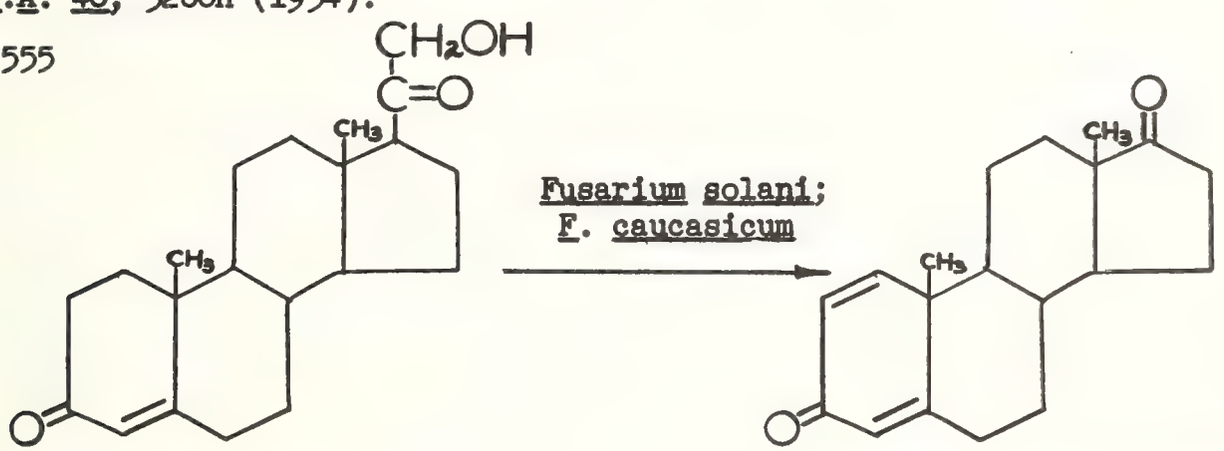
14α-hydroxyprogesterone

14α-hydroxy-Δ^4-androstene-3, 17-dione

Vischer and Wettstein, Experientia 9, 371-2 (1953).

C.A. 48, 5268h (1954).

Rx. 555



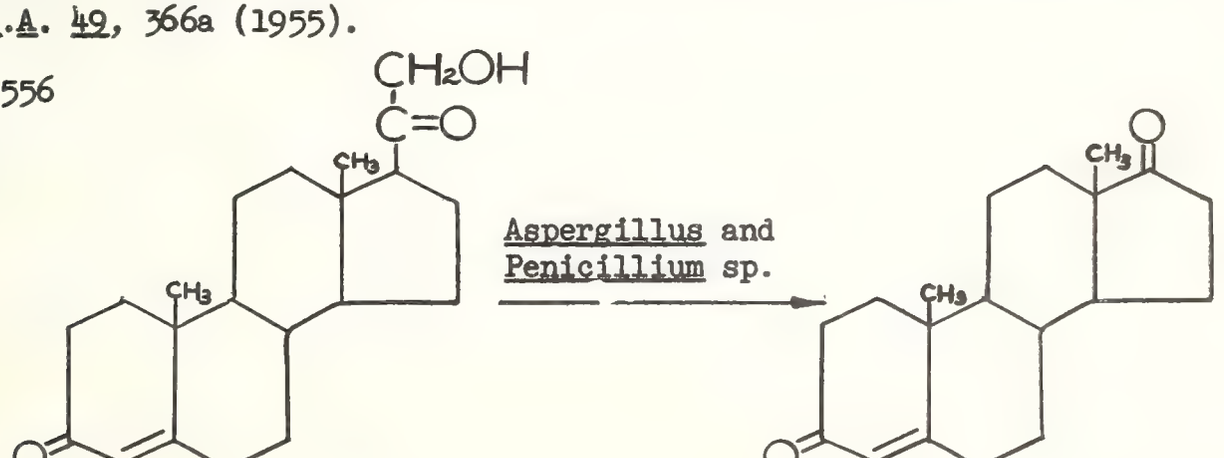
11-desoxycorticosterone (cortexone)

$\Delta^{1,4}$-androstadiene-3,17-dione

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953). (Footnote 5)

C.A. 49, 366a (1955).

Rx. 556



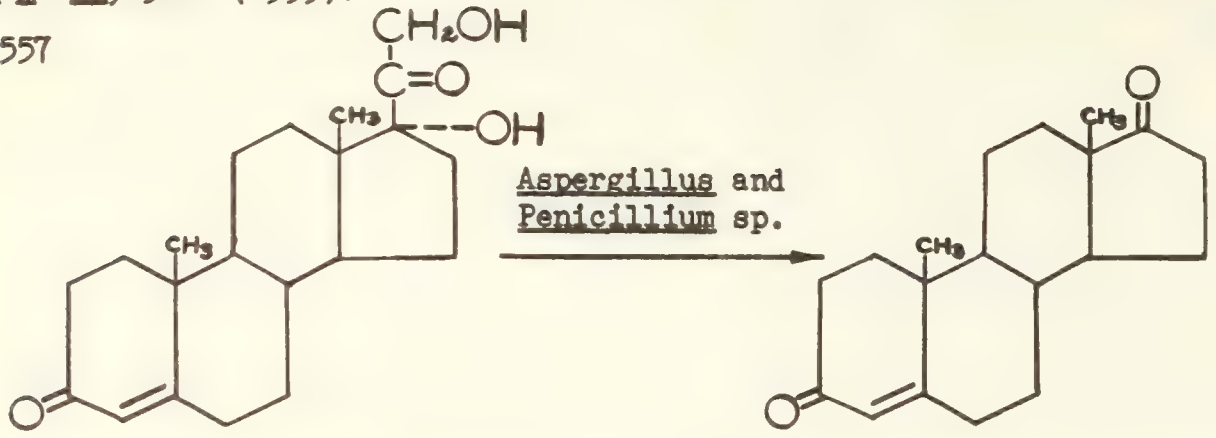
11-desoxycorticosterone

Δ^4-androstene-3,17-dione

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953). (Footnote 5)

C.A. 49, 366a (1955).

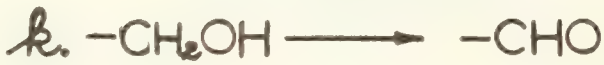
Rx. 557



17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd. S)

Δ^4-androstene-3,17-dione

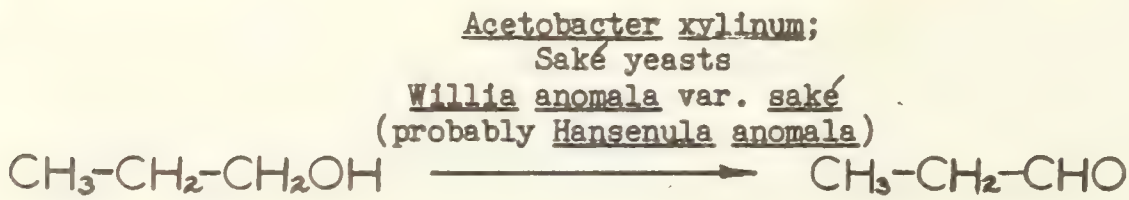
I. Oxidation



Yamada, Bull. Agr. Chem. Soc. Japan 3, 76-83 (1927).

C.A. 22, 8415 (1928).

Rx. 558

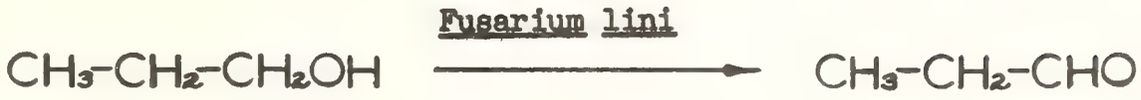


1-propanol

propionaldehyde

Goepfert, J. Biol. Chem. 140, 525-34 (1941).
C.A. 35, 6618[1] (1941).

Rx. 559



1-propanol — propionaldehyde (very low yield)

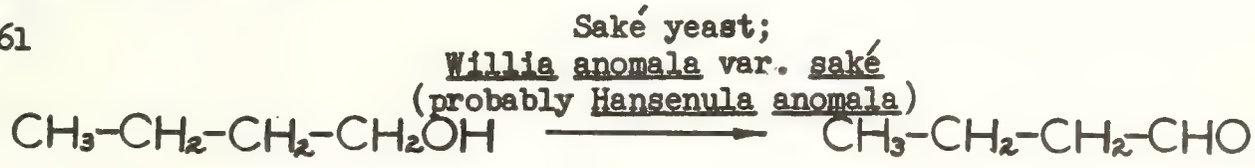
Goepfert and Nord, Arch. Biochem. 1, 289-301 (1942).
C.A. 37, 1134[9] (1943).

Rx. 560

glycerol — glycerose

Yamada, Bull. Agr. Chem. Soc. Japan 3, 76-83 (1927).
C.A. 22, 841[5] (1928).

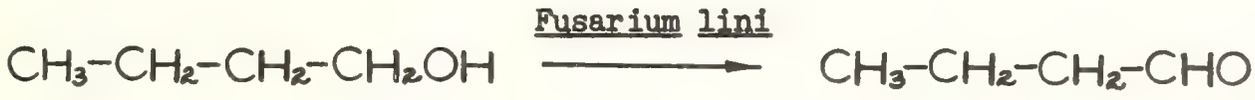
Rx. 561



1-butanol — n-butyraldehyde

Goepfert, J. Biol. Chem. 140, 525-34 (1941).
C.A. 35, 6618[1] (1941).

Rx. 562

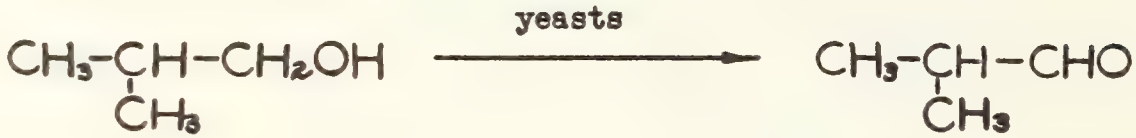


1-butanol — n-butyraldehyde (very low yield)

Yamada, Bull. Agr. Chem. Soc. Japan 3, 76-83 (1927).

C.A. 22, 841[5] (1928).

Rx. 563

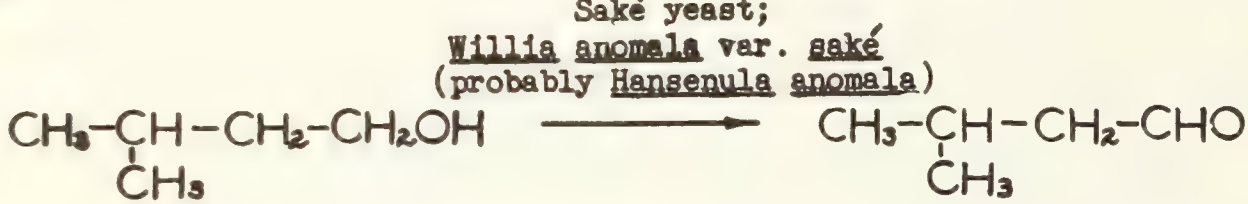


2-methyl-1-propanol — 2-methylpropionaldehyde

Yamada, Bull. Agr. Chem. Soc. Japan 3, 76-83 (1927).

C.A. 22, 841[5] (1928).

Rx. 564

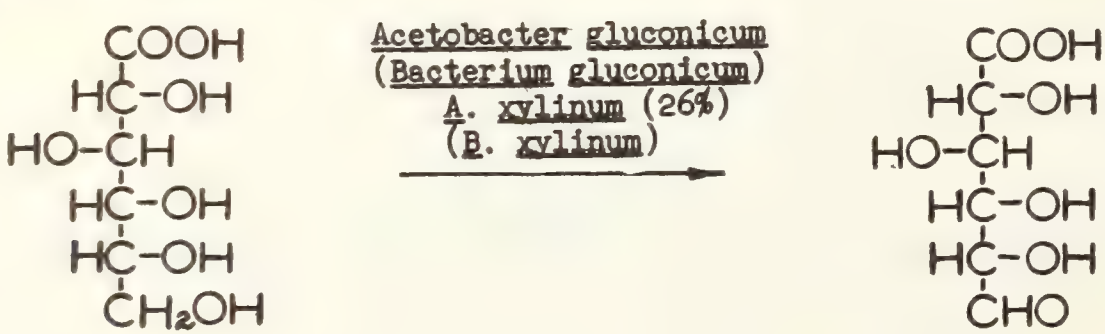


3-methyl-1-butanol — 3-methylbutyraldehyde

Bernhauer and Irrgang, Biochem. Z. 280, 360-6 (1935).

C.A. 30, 1085[1] (1936).

Rx. 565



gluconic acid — aldehydogluconic acid

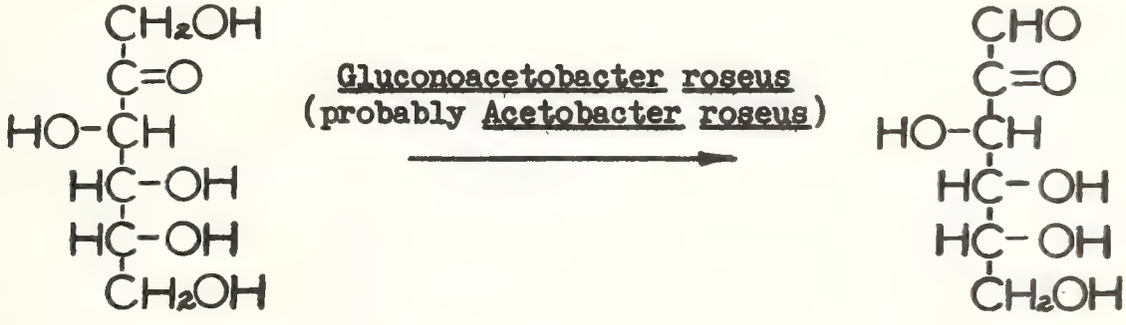
Hockenhull et al., Biochem. J. 50, 605-9 (1952).
C.A. 46, 5129d (1952).

Rx. 566

benzyl alcohol — benzaldehyde

Ikeda, J. Agr. Chem. Soc. Japan 28, 538-43 (1954). See Ikeda, ibid. 26, 90-5 (1952). C.A. 48, 10113h (1954).
C.A. 50, 16964i (1956).

Rx. 567



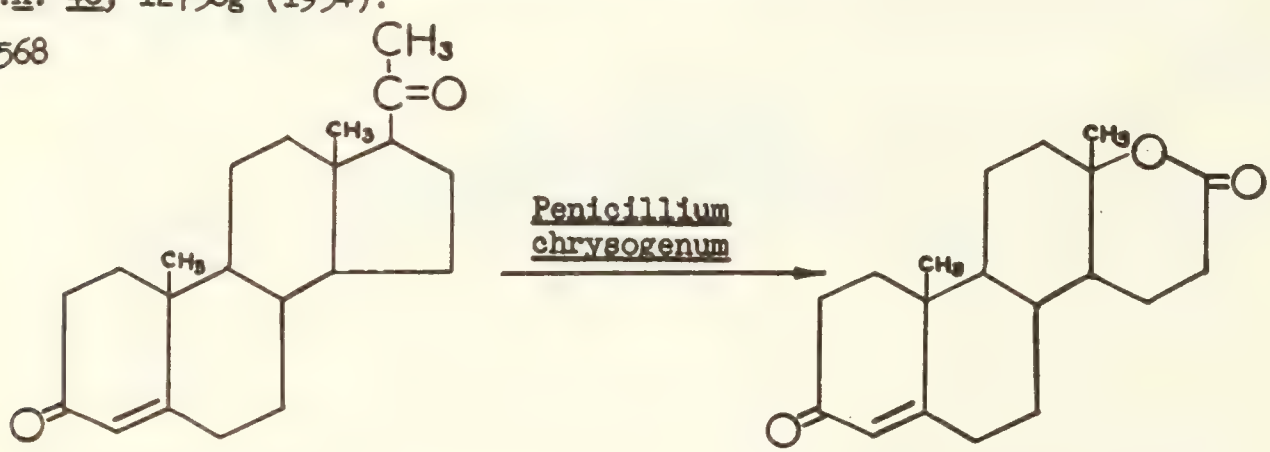
fructose — glucosone

I. Oxidation

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 568

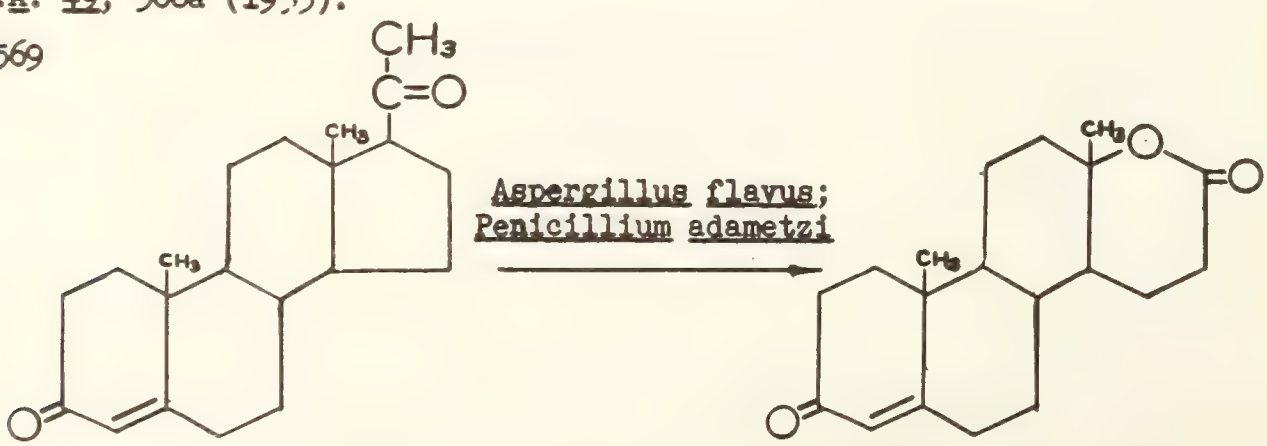


progesterone — testololactone (70%)

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953).

C.A. 49, 366a (1955).

Rx. 569

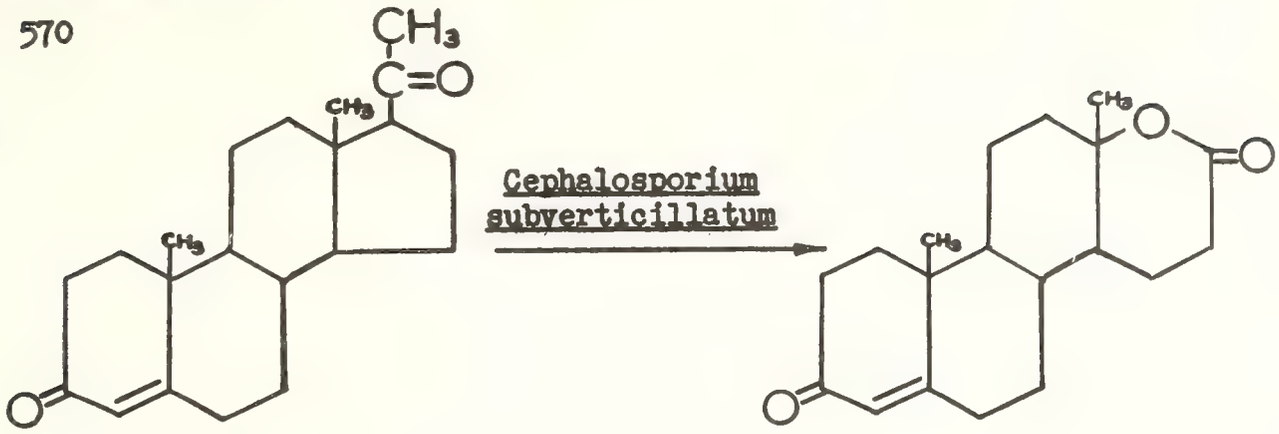


progesterone — testololactone

Bodánszky et al., Experientia 11, 384 (1955).

C.A. 50, 4290d (1956).

Rx. 570

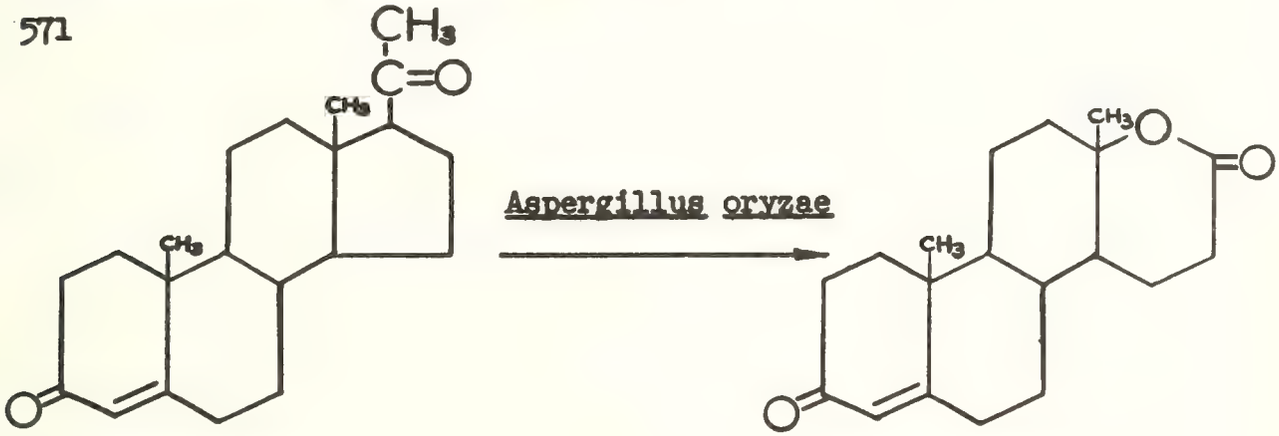


progesterone — testololactone (approx. 54%)

Čapek et al., Naturwissenschaften 43, 471 (1956).

C.A. reference not available.

Rx. 571

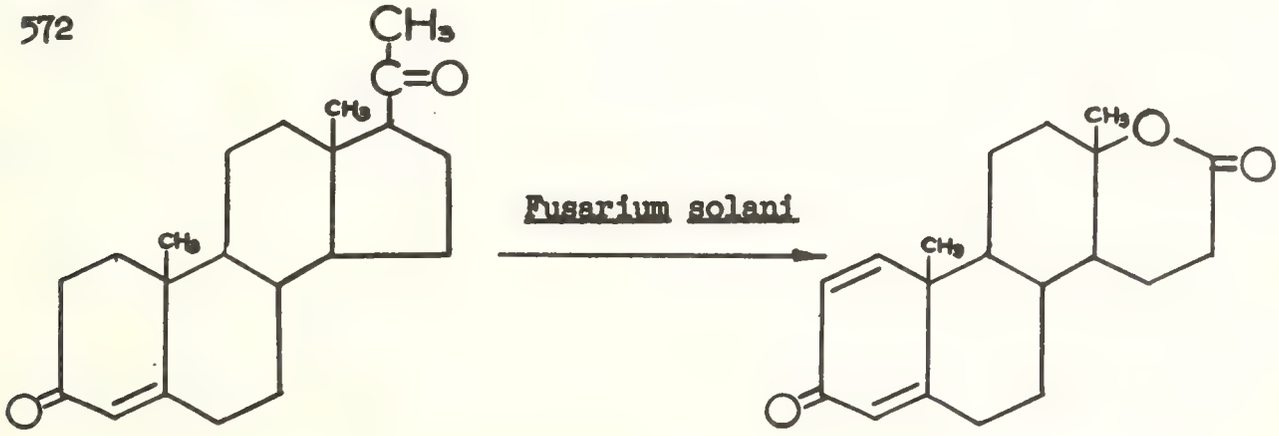


progesterone — testololactone

Szpilfogel et al., Rec. trav. chim. 75, 402-4 (1956).

C.A. 50, 13162a (1956).

Rx. 572

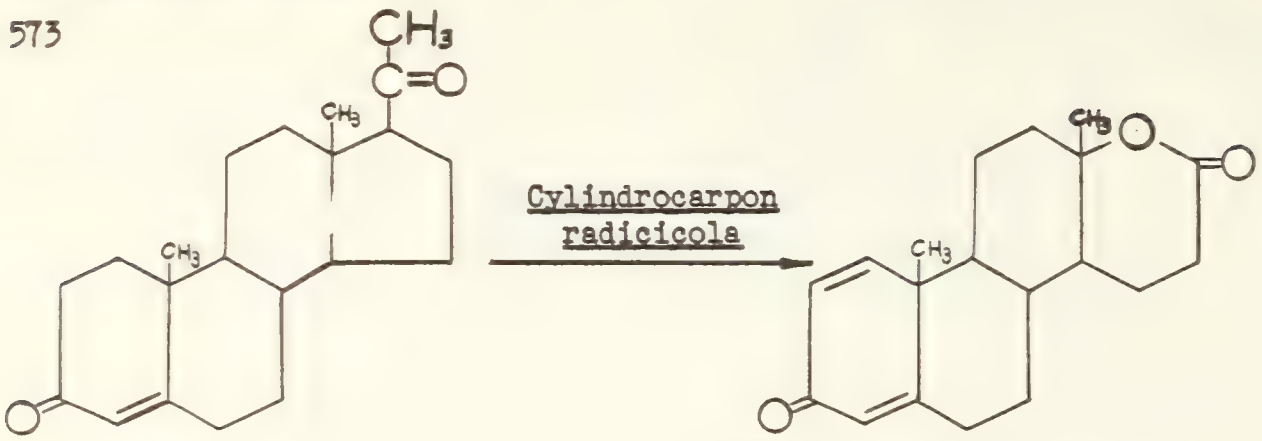


progesterone — Δ^1-dehydrotestololactone

Peterson et al., J. Bacteriol. 74, 684-8 (1957).

C.A. 52, 3021c (1958).

Rx. 573



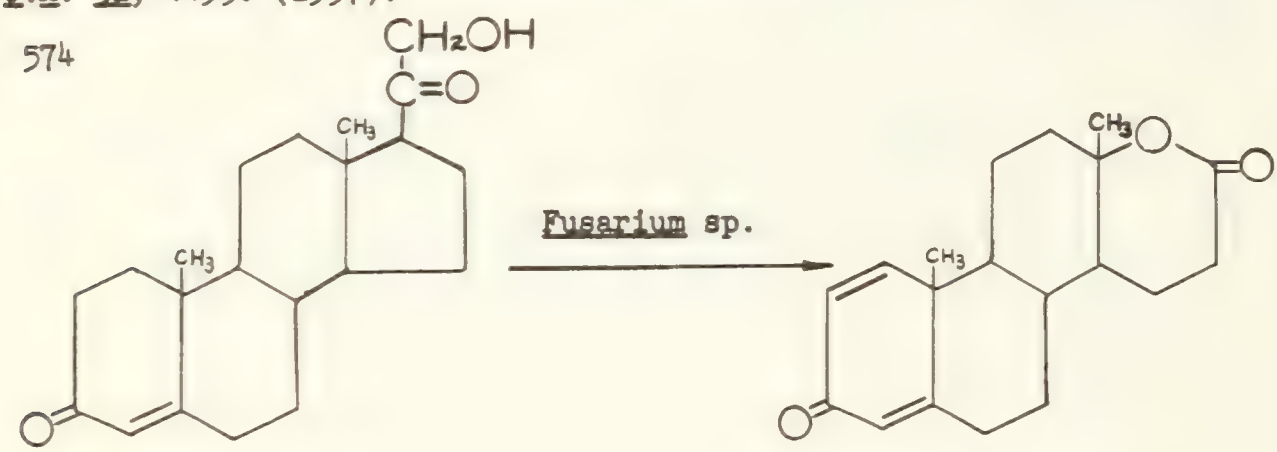
progesterone

Δ^1-dehydrotestololactone

Shull and Bloom, in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 574



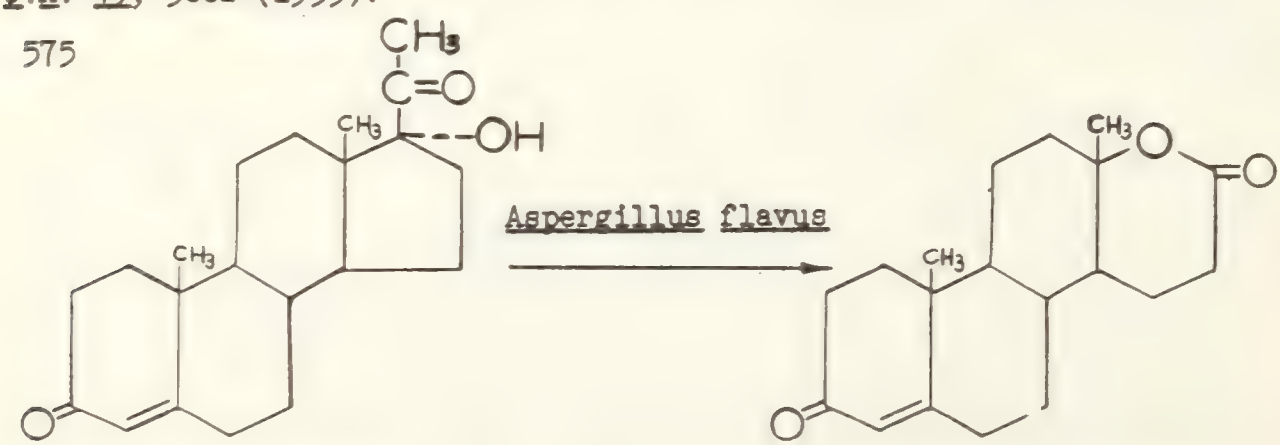
11-desoxycorticosterone (cortexone)

Δ^1-dehydrotestololactone

Peterson et al., J. Am. Chem. Soc. 75, 5768-9 (1953).

C.A. 49, 366a (1955).

Rx. 575



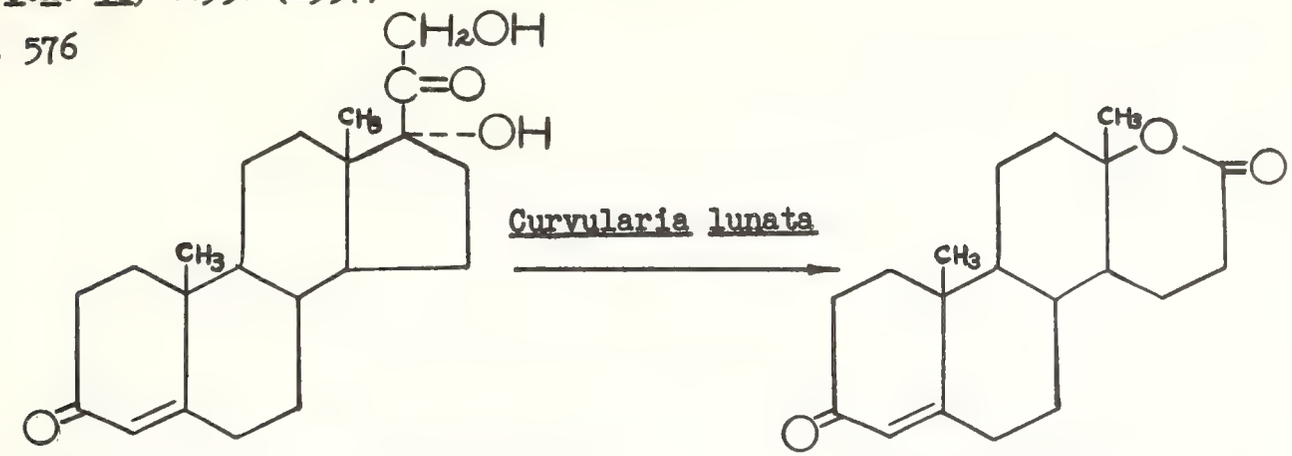
17α-hydroxyprogesterone

testololactone

Kita and Bloom, in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

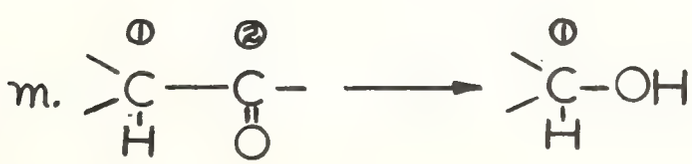
Rx. 576



17α-hydroxy-11-desoxycorticosterone

testololactone

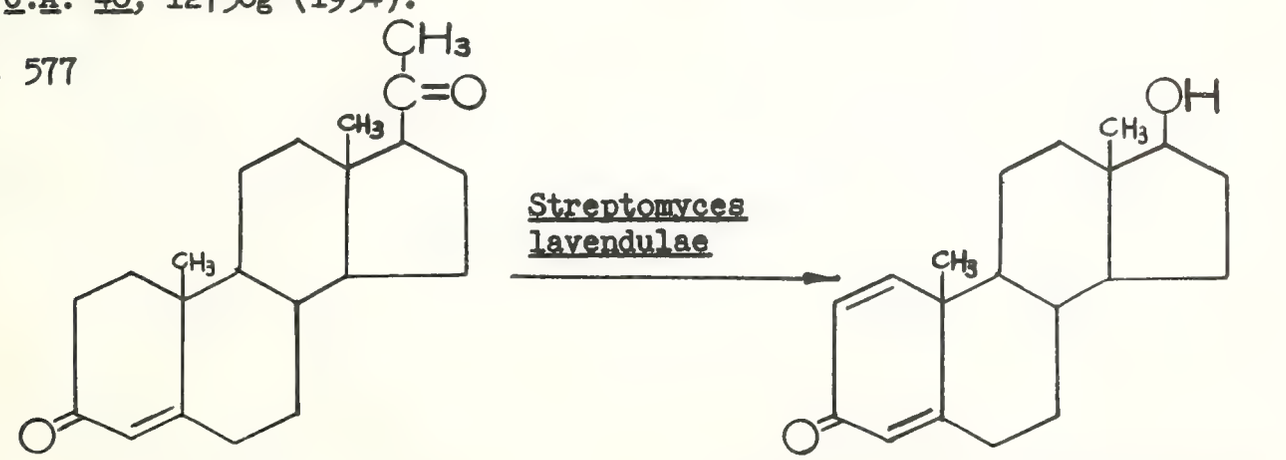
I. Oxidation



Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 577



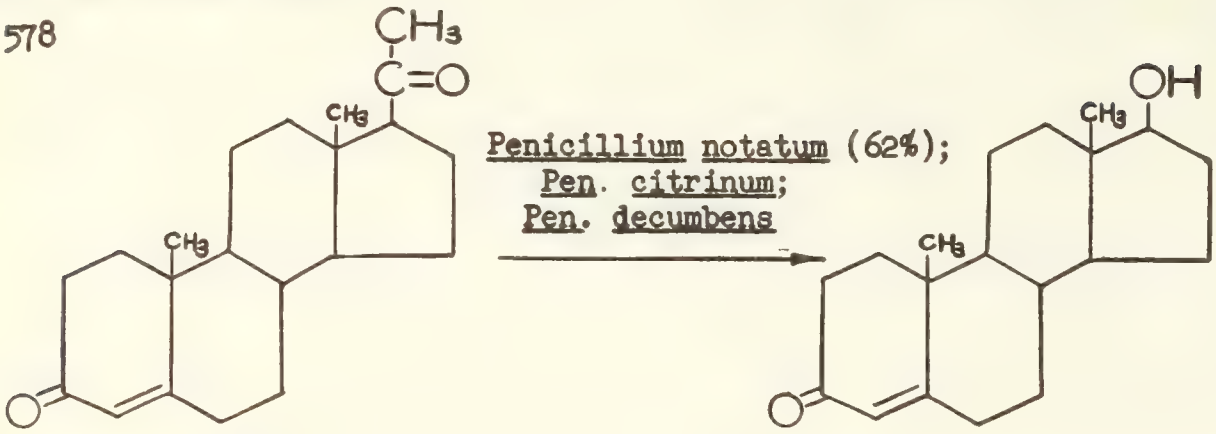
progesterone

$\Delta^{1,4}$-androstadiene-17β-ol-3-one
(12%)

Hanč et al., Arzneimittel-Forsch. 7, 175-6 (1957).

C.A. 51, 9796h (1957).

Rx. 578

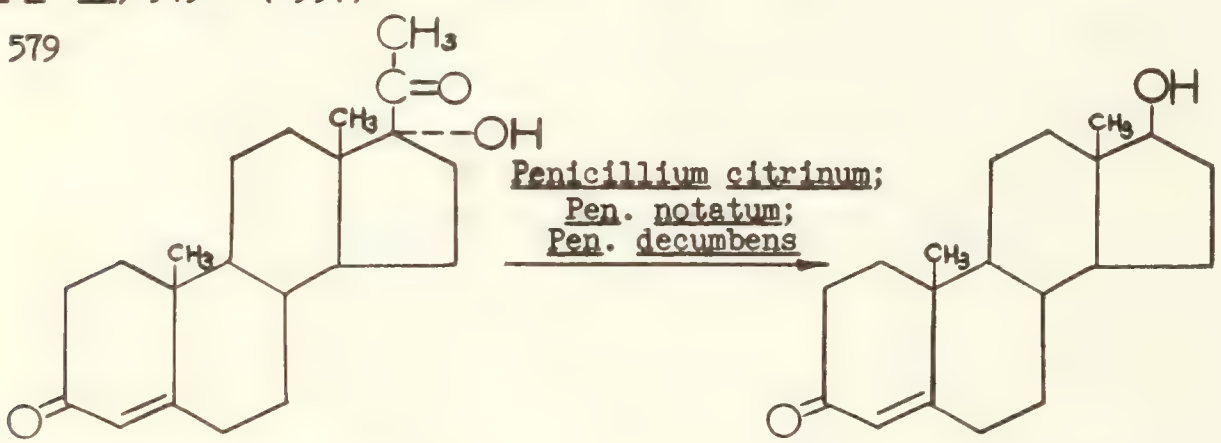


progesterone — testosterone

Hanč et al., Arzneimittel-Forsch. 7, 175-6(1957).

C.A. 51, 9796h (1957).

Rx. 579

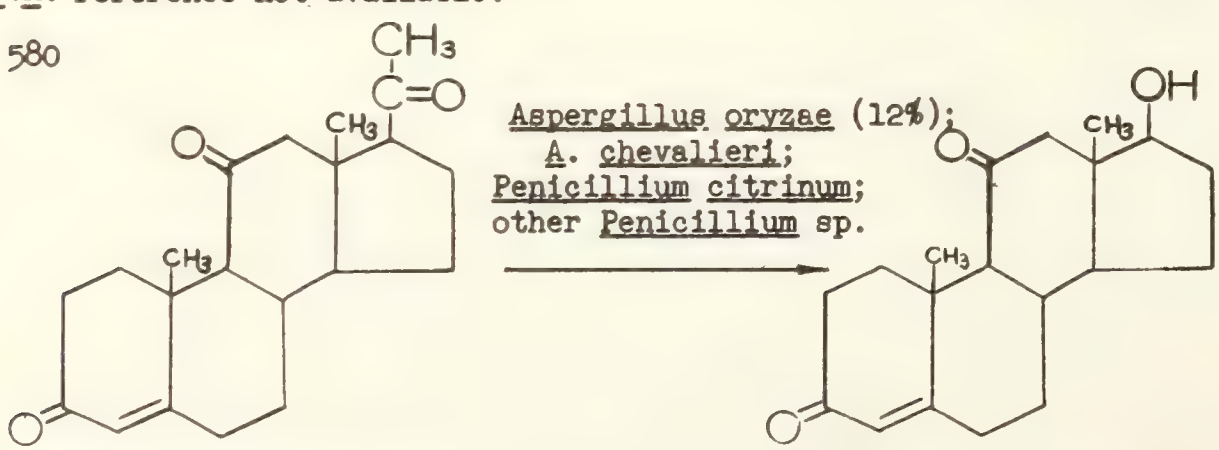


17α-hydroxyprogesterone — testosterone

Čapek et al., Naturwissenschaften 43, 471 (1956).

C.A. reference not available.

Rx. 580

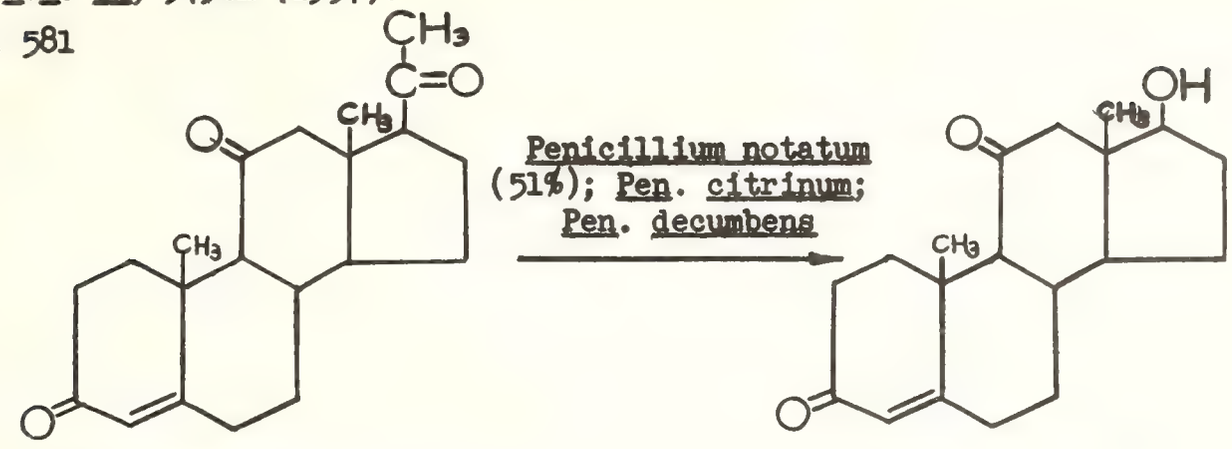


11-ketoprogesterone — 11-ketotestosterone

Hanč *et al.*, Arzneimittel-Forsch. 7, 175-6 (1957).

C.A. 51, 9796h (1957).

Rx. 581



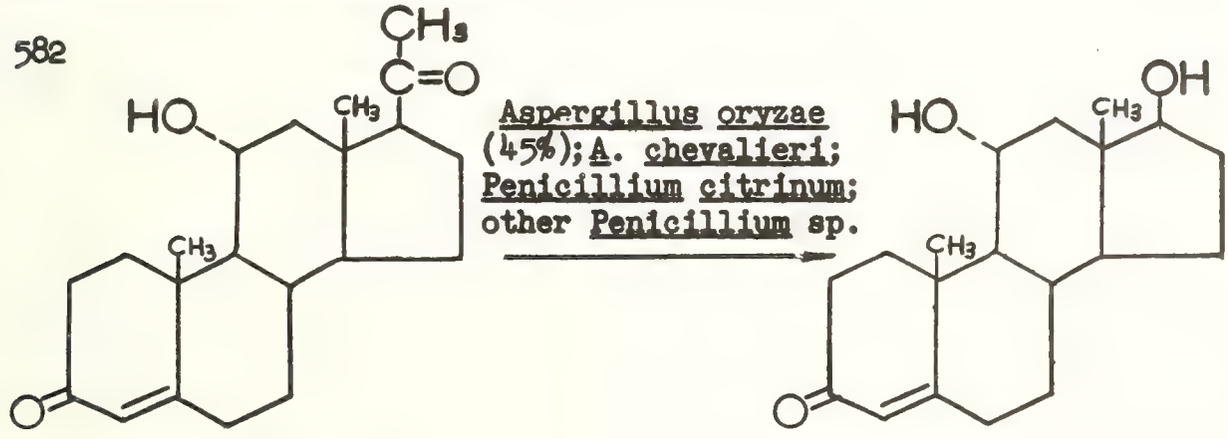
11-ketoprogesterone

11-ketotestosterone

Čapek *et al.*, Naturwissenschaften 43, 471 (1956).

C.A. reference not available.

Rx. 582



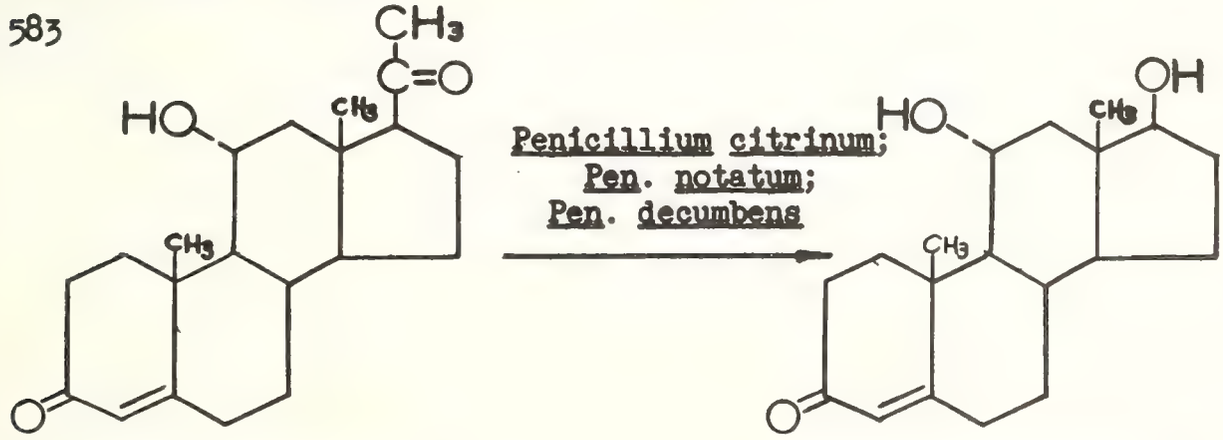
11α-hydroxyprogesterone

11α-hydroxytestosterone

Hanč *et al.*, Arzneimittel-Forsch. 7, 175-6 (1957).

C.A. 51, 9796h (1957).

Rx. 583



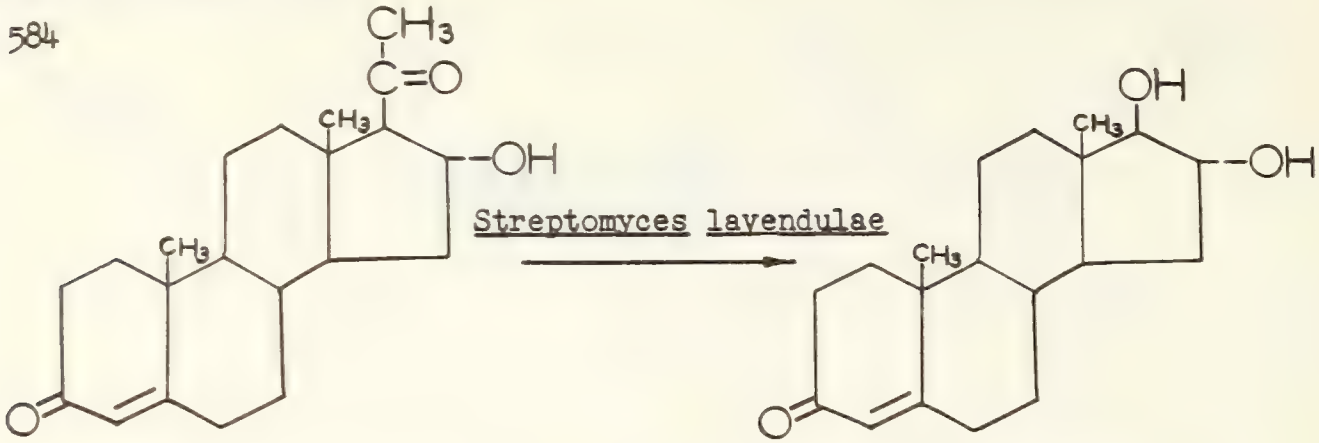
11α-hydroxyprogesterone

11α-hydroxytestosterone

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 584



16α-hydroxyprogesterone

16α-hydroxytestosterone

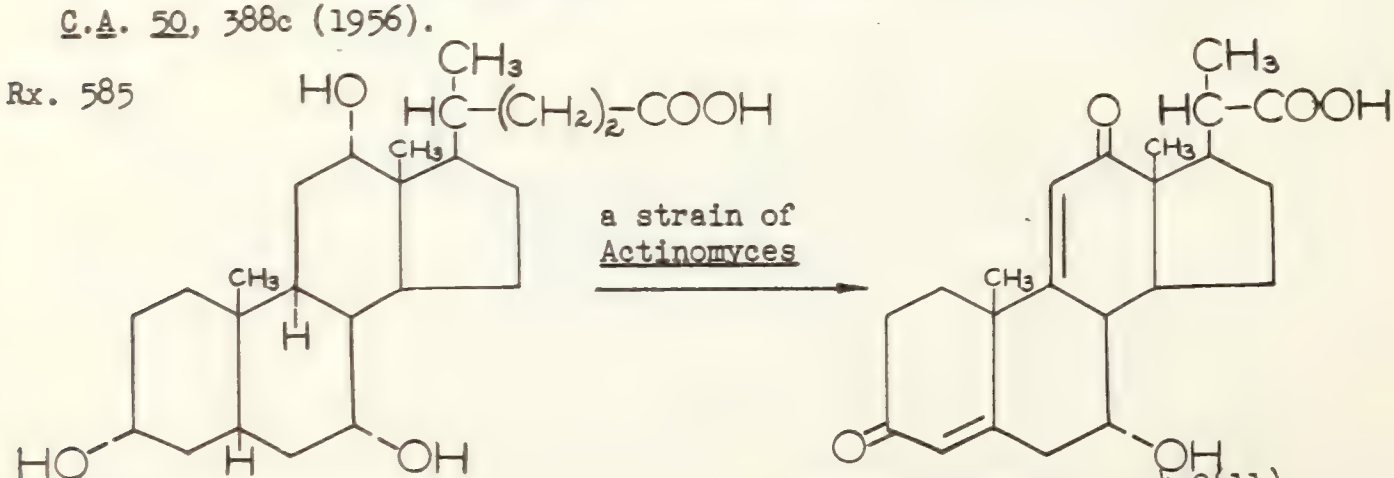
I. Oxidation

n. $-CH_2-\overset{|}{C}H-$ ⟶ $-CH=\overset{|}{C}-$

Hayakawa, Proc. Japan Acad. 30, 133-8 (1954).

C.A. 50, 388c (1956).

Rx. 585



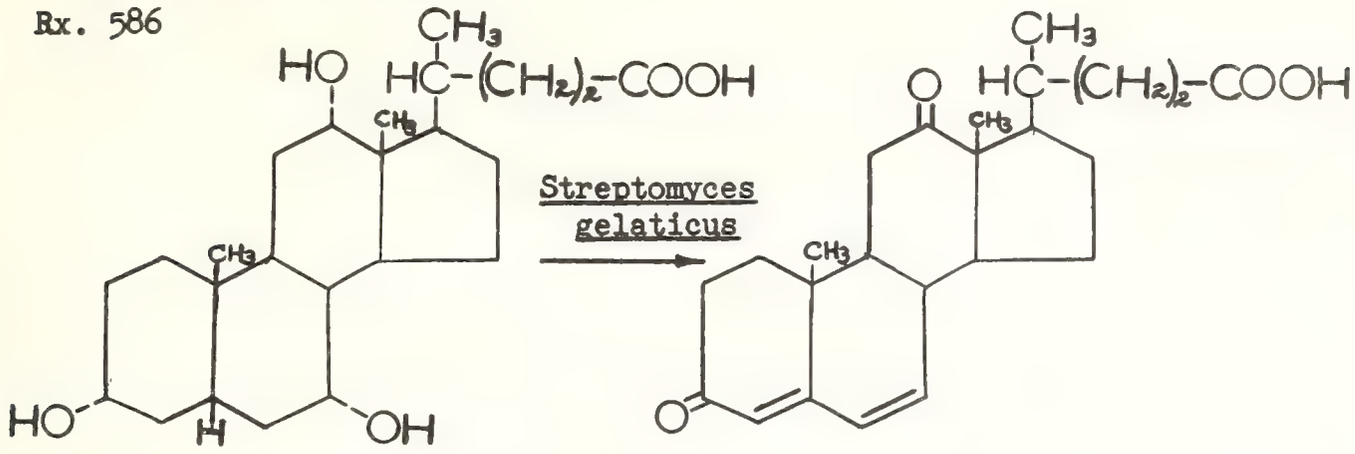
cholic acid

probably 7α-hydroxy-$\Delta^{4,9(11)}$-3,12-diketobisnor-choladienic acid (approx. 7.3%)

Hayakawa et al., Proc. Japan Acad. 32, 519-22 (1956).

C.A. 51, 2111f (1957).

Rx. 586



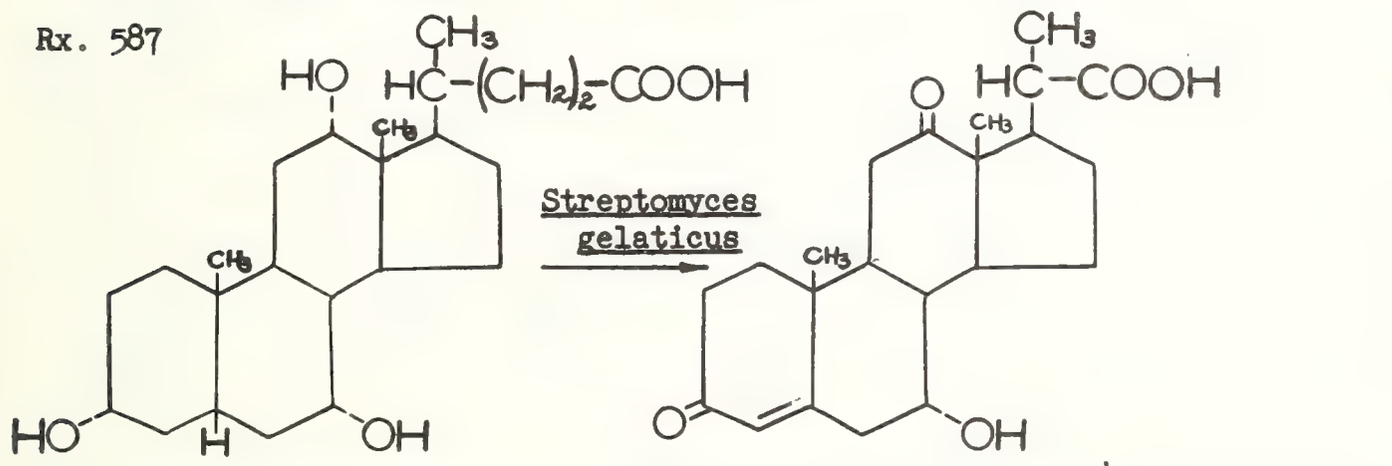
cholic acid

3,12-diketo-$\Delta^{4,6}$-choladienic acid

Hayakawa et al., J. Biochem. (Japan) 43, 723-30 (1956).

C.A. 51, 2111d (1957).

Rx. 587



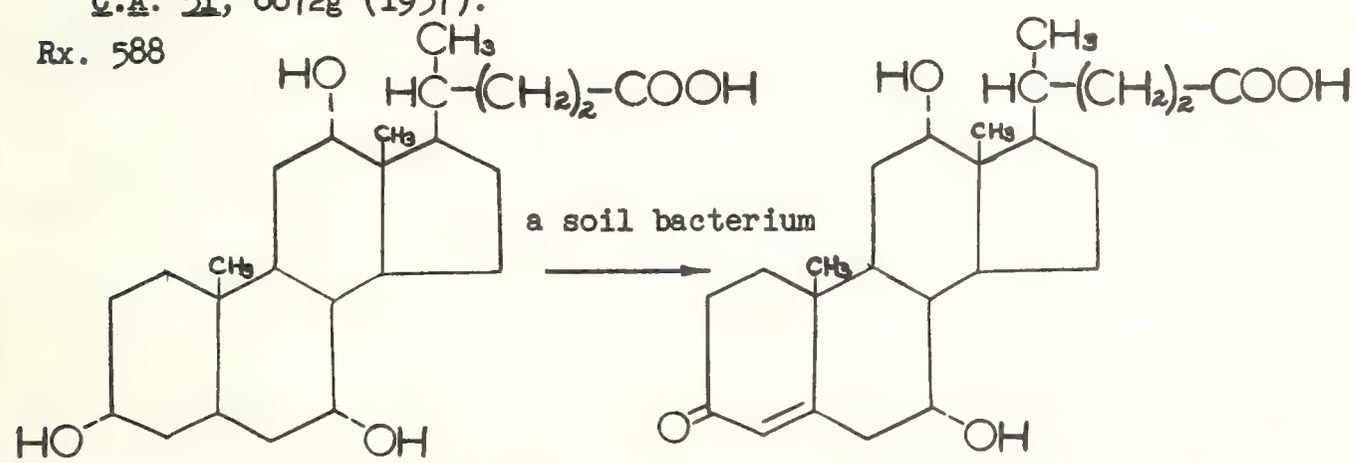
cholic acid

7α-hydroxy-3,12-diketo-Δ^{4}-bisnorcholenic acid

Eguchi, J. Biochem. (Japan) 44, 81-5 (1957).

C.A. 51, 8872g (1957).

Rx. 588



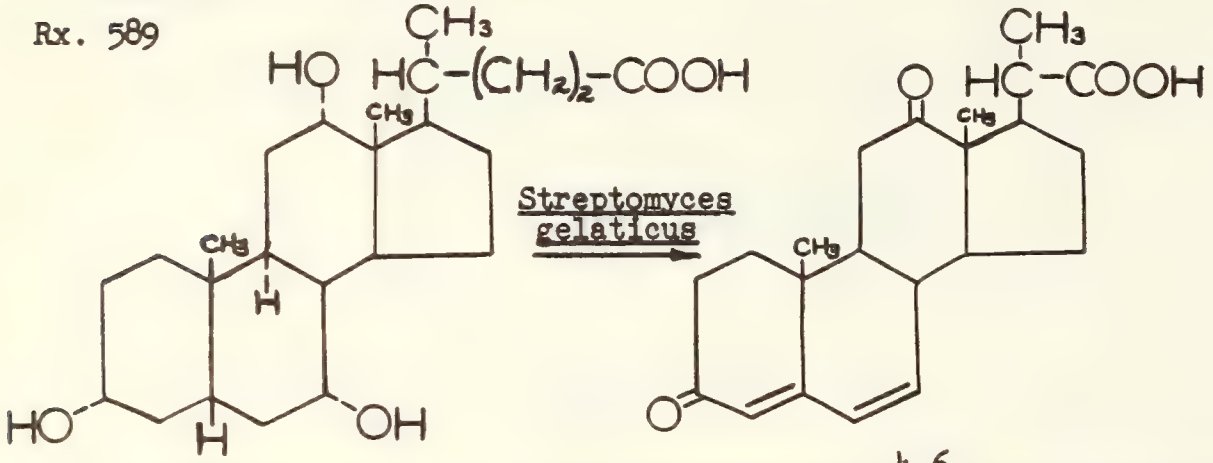
cholic acid

probably 7α,12α-dihydroxy-3-keto-Δ^{4}-cholenic acid

Hayakawa et al., J. Biochem. (Japan) 44, 109-13 (1957).

C.A. 51, 8872h (1957).

Rx. 589



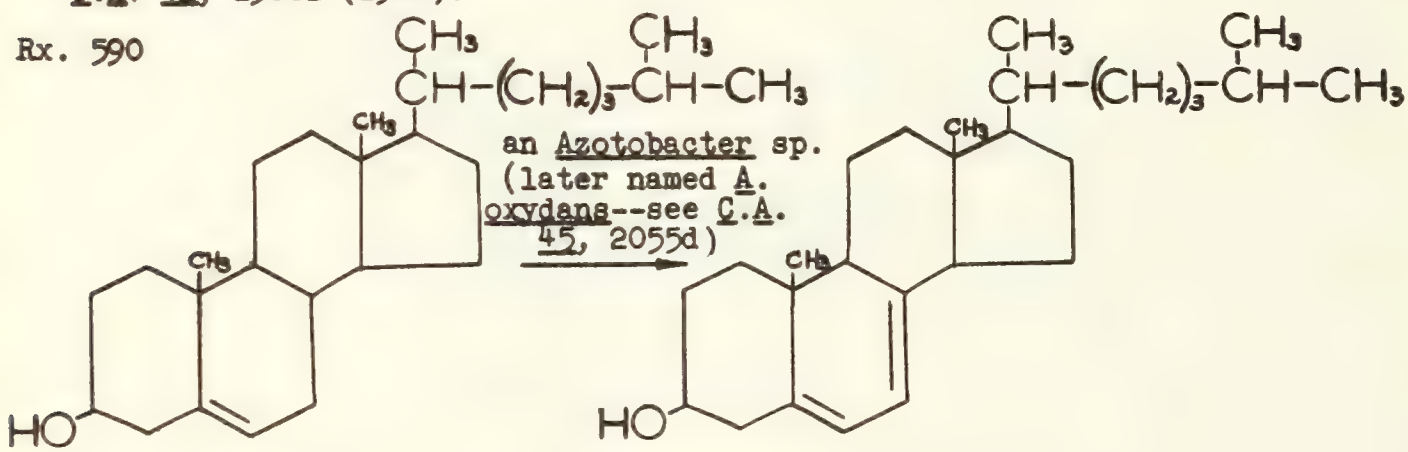
cholic acid

3,12-diketo-$\Delta^{4,6}$-bisnorcholadienic acid

Horváth and Krámli, Nature 160, 639 (1947).

C.A. 42, 1986i (1948).

Rx. 590



cholesterol

Δ^{7}-dehydrocholesterol

I. Oxidation

$$\sigma.\ -CH{=}CH- \longrightarrow -\overset{\overset{O}{\|}}{C}-CH_2-$$

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).
C.A. 37, 155[1] (1943).

Rx. 591

$$CH_3-CH{=}CH-COOH \xrightarrow{\text{Penicillium glaucum}} CH_3-\overset{\overset{O}{\|}}{C}-CH_3$$

crotonic acid — acetone

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).
C.A. 37, 155[1] (1943).

Rx. 592

$$CH_3-(CH_2)_2-CH{=}CH-COOH \xrightarrow{\text{Penicillium glaucum}} CH_3-CH_2-CH_2-\overset{\overset{O}{\|}}{C}-CH_3$$

2-hexenoic acid — 2-pentanone

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).
C.A. 37, 155[1] (1943).

Rx. 593

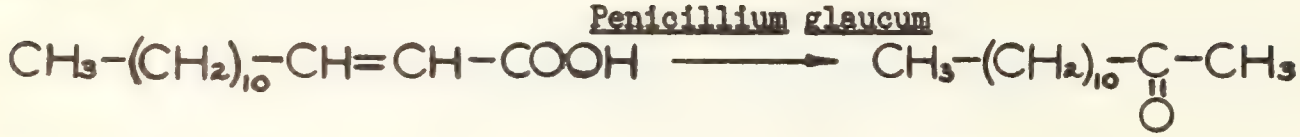
$$CH_3-(CH_2)_6-CH{=}CH-COOH \xrightarrow{\text{Penicillium glaucum}} CH_3-(CH_2)_6-\overset{\overset{O}{\|}}{C}-CH_3$$

2-decenoic acid — 2-nonanone

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).

C.A. 37, 155[1] (1943).

Rx. 594

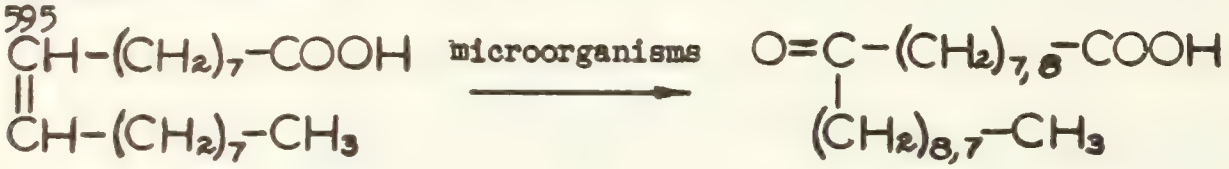


2-tetradecenoic acid — 2-tridecanone (n-undecylmethyl ketone)

Pigulewski and Charik, Biochem. Z. 200, 201-10 (1928).

C.A. 23, 629[9] (1929).

Rx. 595



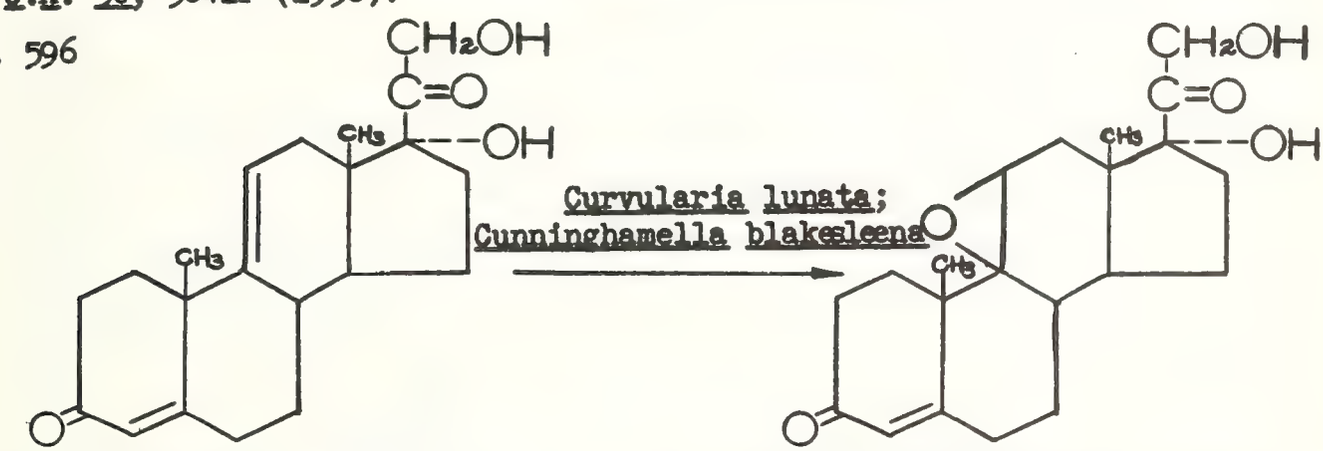
oleic acid — (9 or 10?)-ketostearic acid

I. Oxidation

Bloom and Shull, J. Am. Chem. Soc. 77, 5767-8 (1955).

C.A. 50, 5842f (1956).

Rx. 596



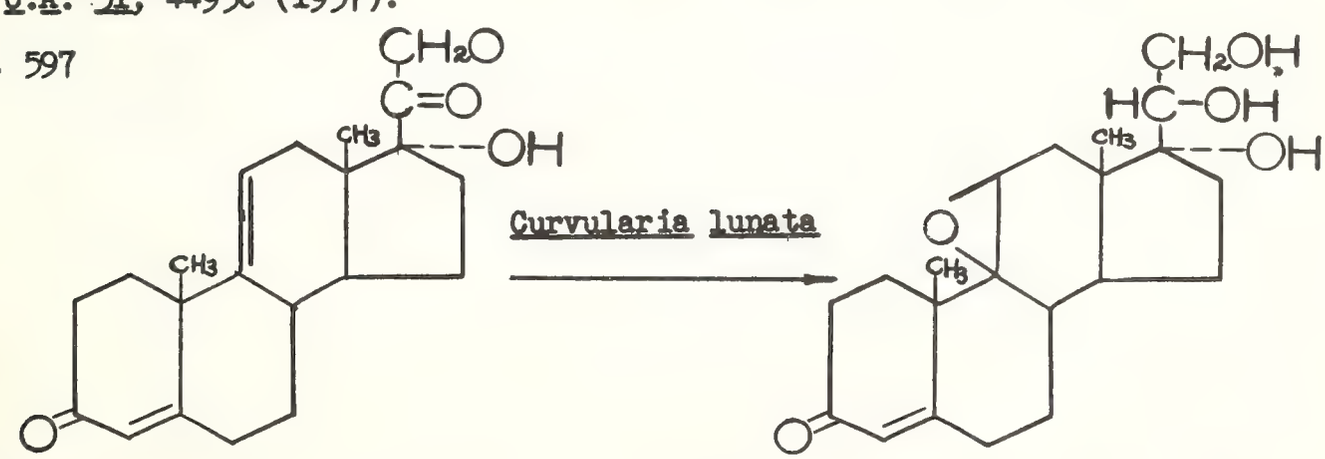
$\Delta^{4,9(11)}$-pregnadiene-17α,21-diol-3,20-dione

Δ^{4}-9β,11β-epoxidopregnene-17α,21-diol-3,20-dione

Bloom et al., in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 597



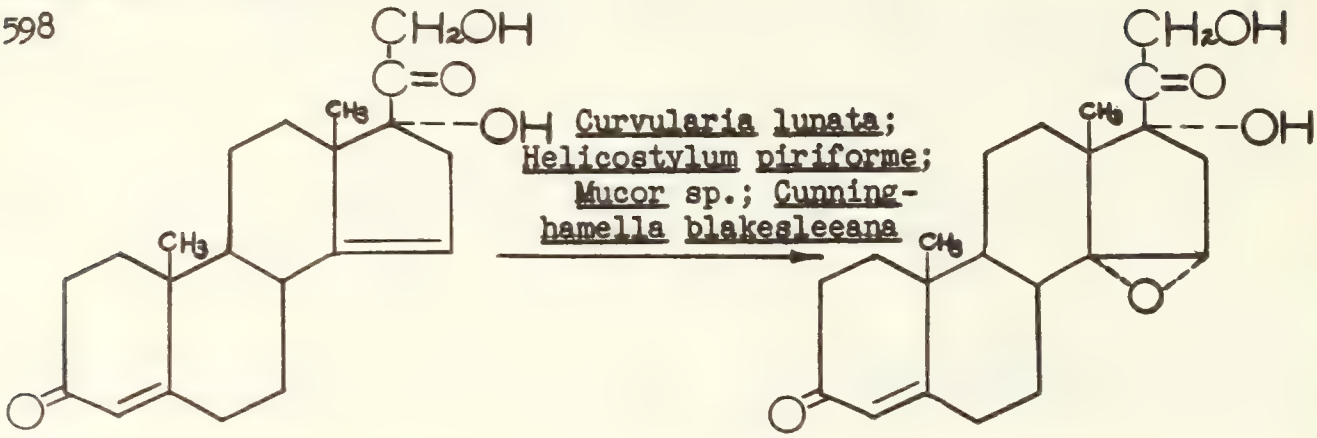
$\Delta^{4,9(11)}$-pregnadiene-17α,21-diol-3,20-dione

Δ^{4}-pregnene-9β,11β-epoxido-17α,20β,21-triol-3-one

Bloom and Shull, J. Am. Chem. Soc. 77, 5767-8 (1955).

C.A. 50, 5842f (1956).

Rx. 598



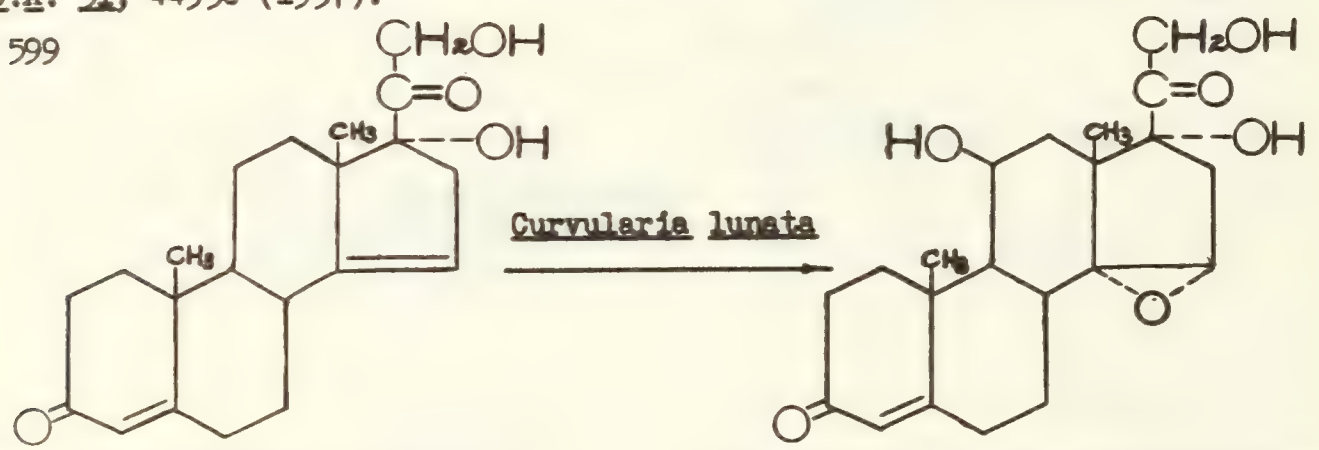
$\Delta^{4,14}$-pregnadiene-17α,21-diol-3,20-dione

Δ^{4}-14α,15α-epoxidopregnene-17α,21-diol-3,20-dione

Bloom et al., in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 599



$\Delta^{4,14}$-pregnadiene-17α,21-diol-3,20-dione

Δ^{4}-14α,15α-epoxidopregnene-11β,17α,21-triol-3,20-dione

I. Oxidation

q. $2\,CH_3- \longrightarrow -CH_2-CH_2-$

Takahashi and Asai, Proc. Imp. Acad. (Japan) 3, 86-9 (1927).

C.A. 21, 3647[3] (1927).

Rx. 600

$$CH_3-COOH \xrightarrow{\text{Rhizopus sp.}} HOOC-CH_2-CH_2-COOH$$

acetic acid (Ca salt) — succinic acid

Butkewitsch and Fedoroff, Biochem. Z. 207, 302-18 (1929).

C.A. 23, 3488[9] (1929).

Rx. 601

$$CH_3-COOH \xrightarrow{\text{Rhizopus nigricans (Mucor stolonifer)}} HOOC-CH_2-CH_2-COOH$$

acetic acid — succinic acid (15-30%)

Wieland and Sonderhoff, Ann. 499, 213-28 (1932).

C.A. 27, 1614[4] (1933).

Rx. 602

$$CH_3-COOH \xrightarrow{\text{impoverished yeast}} HOOC-CH_2-CH_2-COOH$$

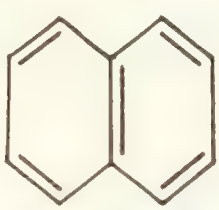
acetic acid — succinic acid (5% of acetic acid consumed)

I. Oxidation

(arom.)
↿ -CH=CH- ⟶ -CH(OH)-CH(OH)-

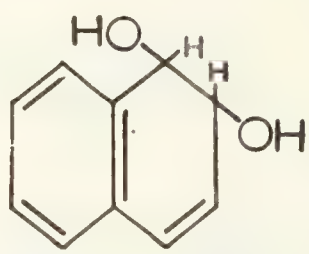
Walker and Wiltshire, J. Gen. Microbiol. 8, 273-6 (1953).
C.A. 47, 6499b (1953).

Rx. 603



naphthalene

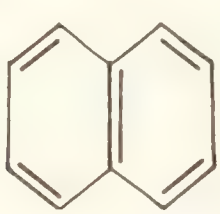
a soil bacterium ⟶



d-trans-1,2-dihydro-1,2-dihydroxynaphthalene

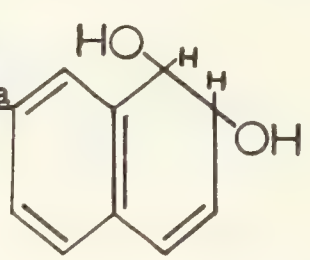
Treccani et al., J. Gen. Microbiol. 11, 341-8 (1954).
C.A. 49, 3309i (1954).

Rx. 604



naphthalene

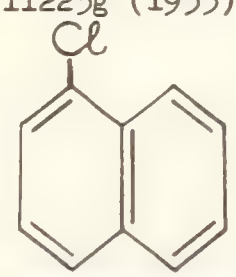
a Pseudomonad closely resembling Pseudomonas desmolyticum; a Nocardia strain; Ps. sp. ⟶



d-trans-1,2-dihydro-1,2-dihydroxynaphthalene

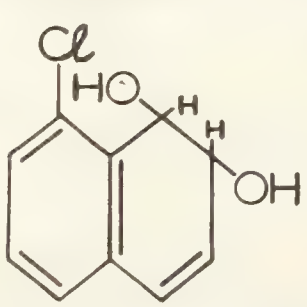
Walker and Wiltshire, J. Gen. Microbiol. 12, 478-83 (1955).
C.A. 49, 11223g (1955).

Rx. 605



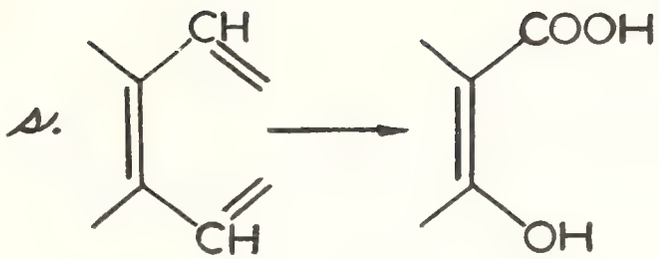
1-chloronaphthalene

a Pseudomonad, possibly Ps. desmolyticum ⟶



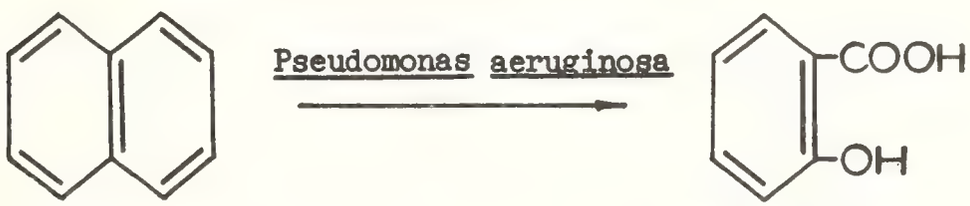
d-8-chloro-1,2-dihydro-1,2-dihydroxynaphthalene

I. Oxidation



Strawinski and Stone, J. Bacteriol. 45, 16 (1943). See Klausmeier and Strawinski, ibid. 73, 461-4 (1957).

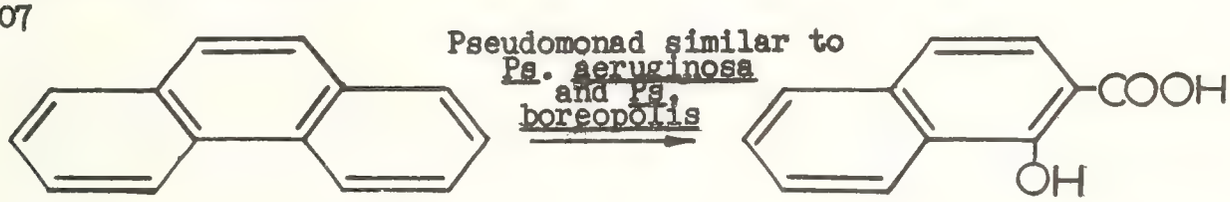
Rx. 606



naphthalene — salicylic acid

Rogoff and Wender, J. Bacteriol. 73, 264-8 (1957).
C.A. 51, 10655f (1957).

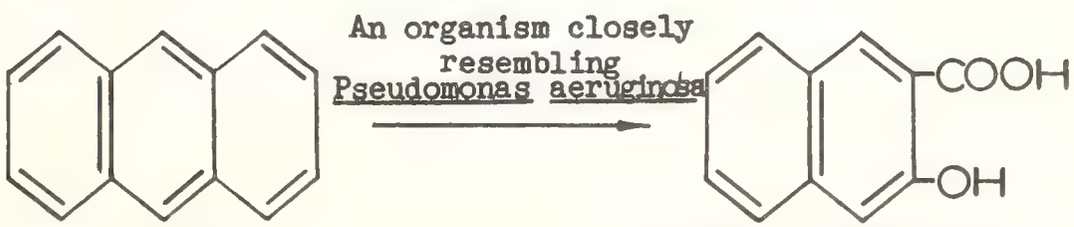
Rx. 607



phenanthrene — 1-hydroxy-2-naphthoic acid

Rogoff and Wender, J. Bacteriol. 74, 108-9 (1957).
C.A. 51, 16701f (1957).

Rx. 608



anthracene — 3-hydroxy-2-naphthoic acid

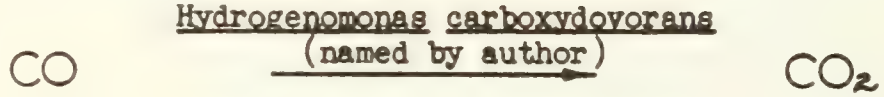
I. Oxidation

t. Miscellaneous Types

Kistner, Koninkl. Ned. Akad. Wetenschap. Proc. 57C, 186-95 (1954). See ibid. 56C, 443-50 (1953).

C.A. 48, 8864a (1954).

Rx. 609

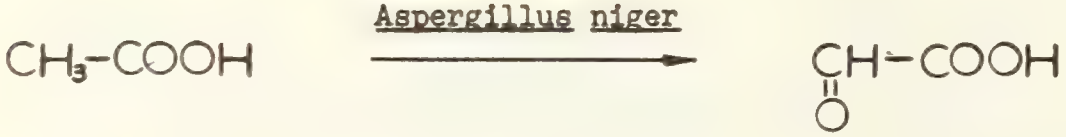


carbon monoxide — carbon dioxide

Challenger et al., J. Chem. Soc., 200-8 (1927).

C.A. 21, 1248[6] (1927).

Rx. 610



acetic acid — glyoxylic acid

Challenger et al., J. Chem. Soc., 200-8 (1927).
C.A. 21, 1248[6] (1927).

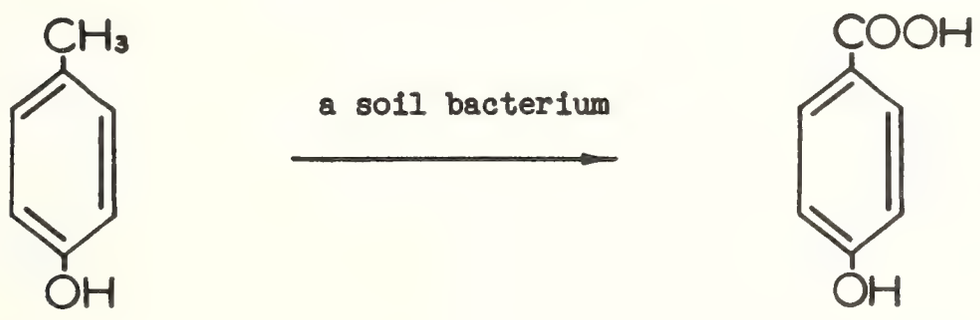
Rx. 611

$$CH_3\text{-}COOH \xrightarrow{\text{Aspergillus niger}} HOOC\text{-}COOH$$

acetic acid — oxalic acid

Smith et al., Biochem. J. 50, xxviii (1952).

Rx. 612



p-cresol — p-hydroxybenzoic acid

Baba, J. Agr. Chem. Soc. Japan 17, 992-4 (1941).
C.A. 41, 4829a (1947).

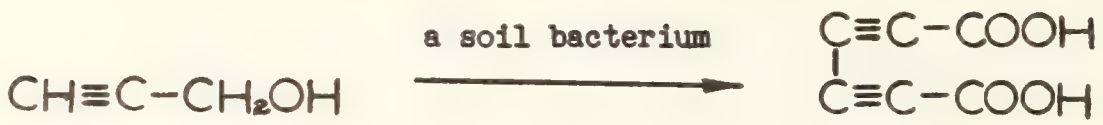
Rx. 613

$$H\text{-}COOH \xrightarrow{\text{Aspergillus niger}} HOOC\text{-}COOH$$

formic acid (ammonium salt) — oxalic acid (35%)

Hanaoka et al., J. Agr. Chem. Soc. Japan 26, 151-4 (1952).
C.A. 48, 10114f (1954).

Rx. 614

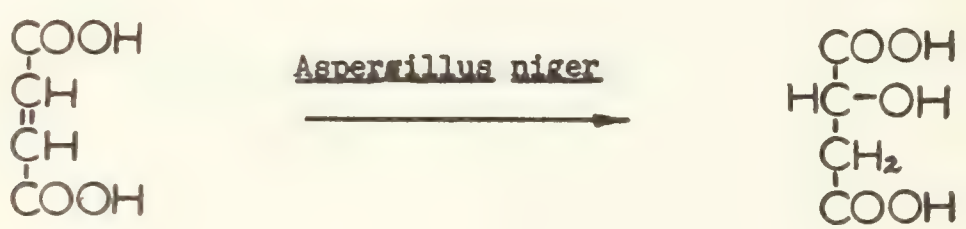


2-propyne-1-ol (propargyl alcohol)

1,3-butadi-yne-1,4-dicarboxylic acid

Challenger and Klein, J. Chem. Soc., 1644-7 (1929).
C.A. 23, 5269[4] (1929).

Rx. 615

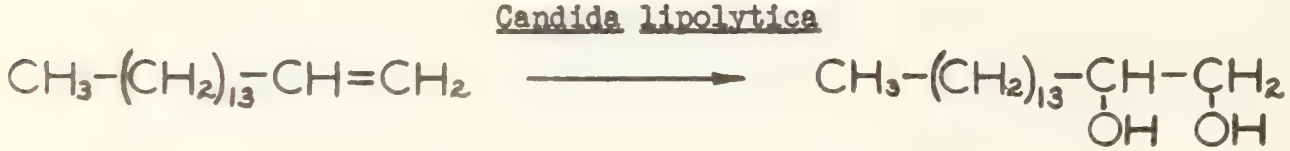


fumaric acid

l-malic acid (40%)

Bruyn, Koninkl. Ned. Akad. Wetenschap. Proc. 57C, 41-5 (1954).
C.A. 48, 8324i (1954).

Rx. 616

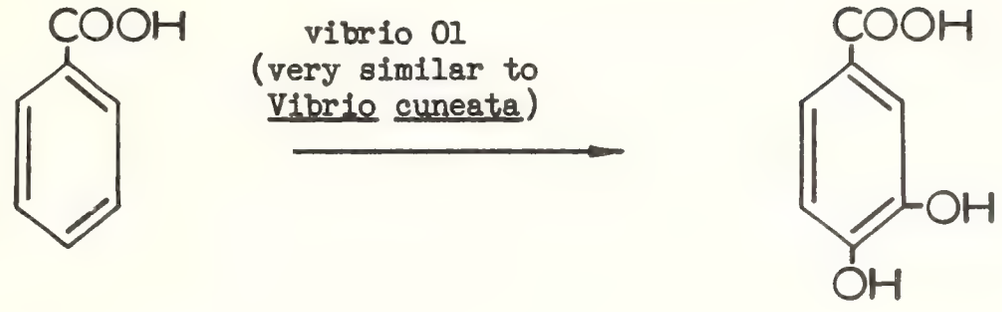


1-hexadecene

1,2-hexadecanediol (5%)

Evans, Biochem. J. 41, 373-82 (1947).
C.A. 42, 6405g (1948).

Rx. 617

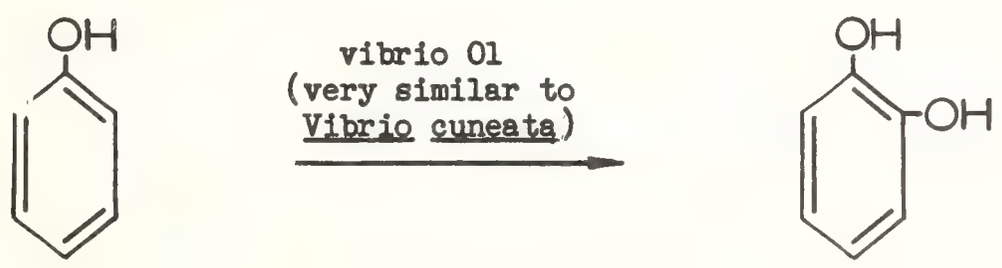


benzoic acid

protocatechuic acid
(3,4-dihydroxybenzoic acid)

Evans, Biochem.J. 41, 373-82 (1947).
C.A. 42, 6405g (1948).

Rx. 618

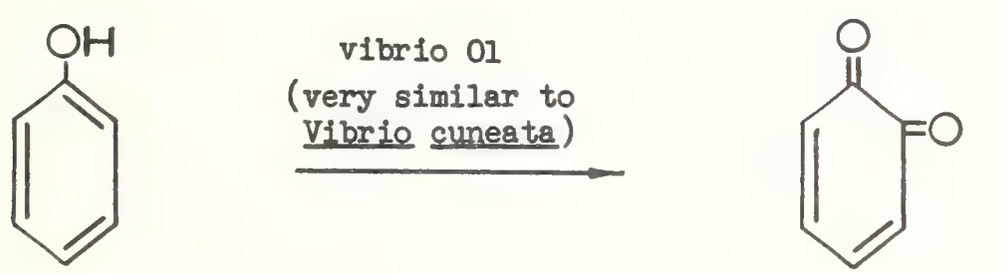


phenol

catechol

Evans, Biochem. J. 41, 373-82 (1947).
C.A. 42, 6405g (1948).

Rx. 619



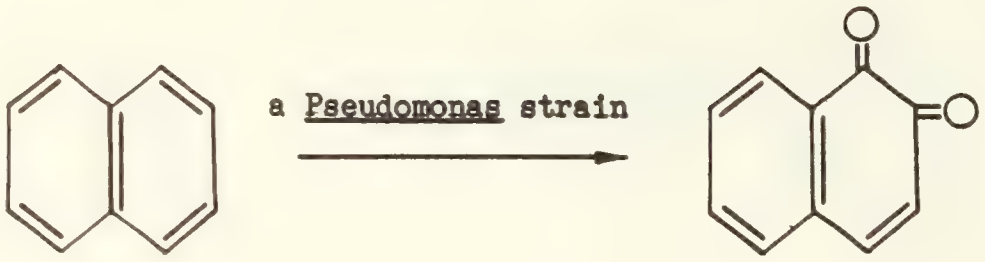
phenol

o-benzoquinone

Murphy and Stone, Can. J. Microbiol. 1, 579-88 (1955).

C.A. 49, 14103f (1955).

Rx. 620

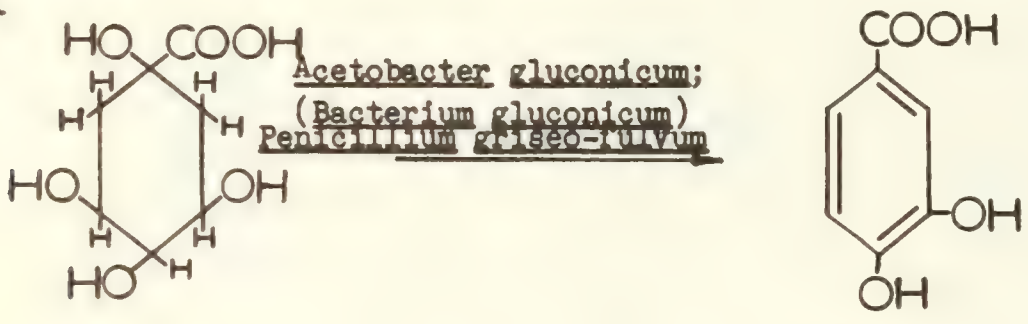


naphthalene — 1,2-naphthoquinone

Bernhauer and Görlich, Biochem. Z. 280, 394-5 (1935).

C.A. 30, 1224 (1936).

Rx. 621

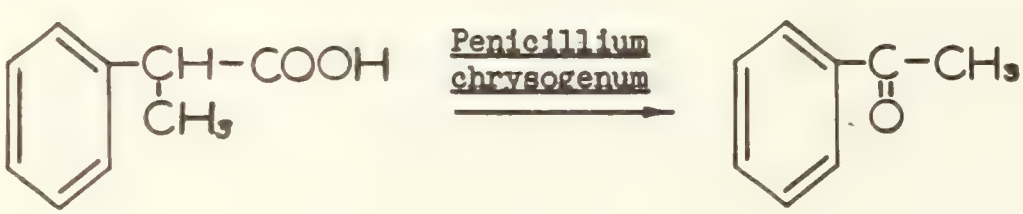


quinic acid — protocatechuic acid

Hockenhull et al., Biochem. J. 50, 605-9 (1952).

C.A. 46, 5129d (1952).

Rx. 622

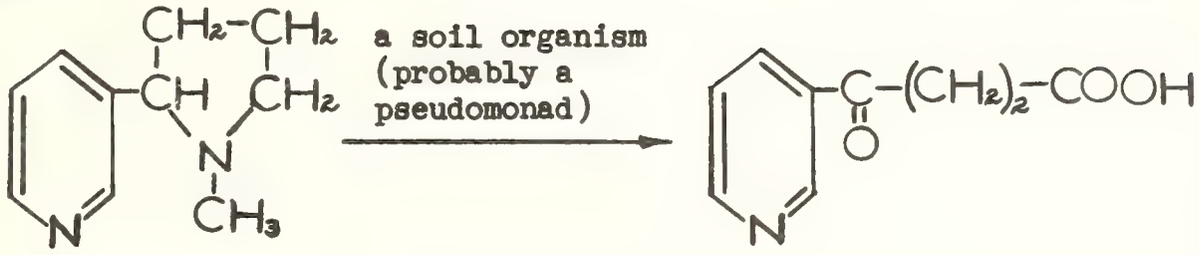


D,L-hydratropic acid
(α-phenylpropionic acid) — acetophenone

Wada and Yamasaki, J. Am. Chem. Soc. 76, 155-7 (1954).

C.A. 49, 1072d (1955).

Rx. 623

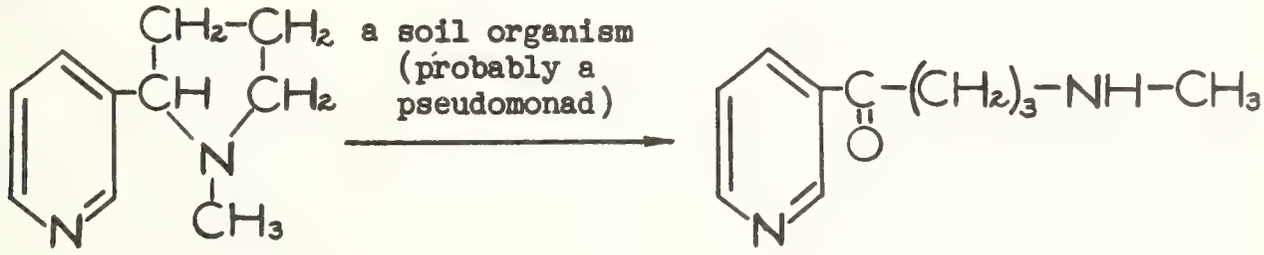


nicotine — 3-nicotinoylpropionic acid

Wada and Yamasaki, J. Am. Chem. Soc. 76, 155-7 (1954).

C.A. 49, 1072d (1955).

Rx. 624

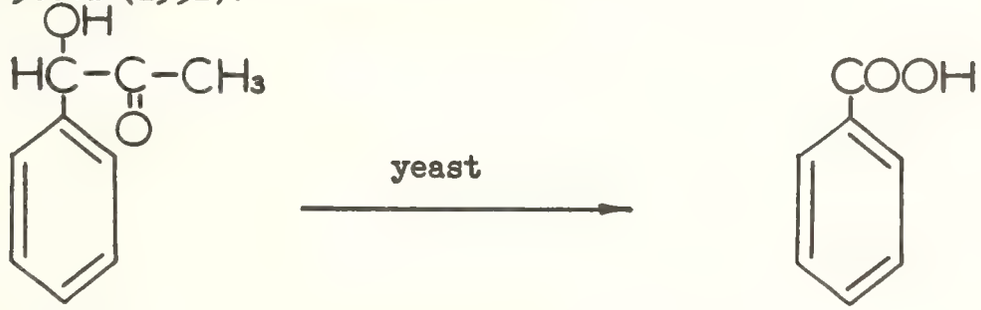


nicotine — pseudooxynicotine

Shimazu, J. Chem. Soc. Japan 71, 503-5 (1950).

C.A. 45, 9004d (1951).

Rx. 625

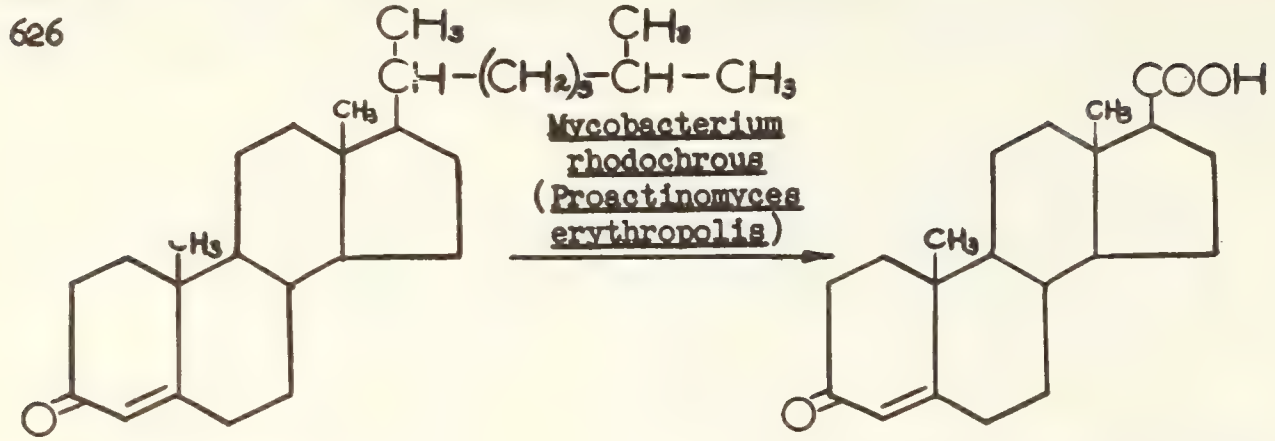


1-phenyl-2-keto-1-propanol
(phenylacetylcarbinol) — benzoic acid

Turfitt, Biochem. J. 42, 376-83 (1948).

C.A. 42, 6406e (1948).

Rx. 626



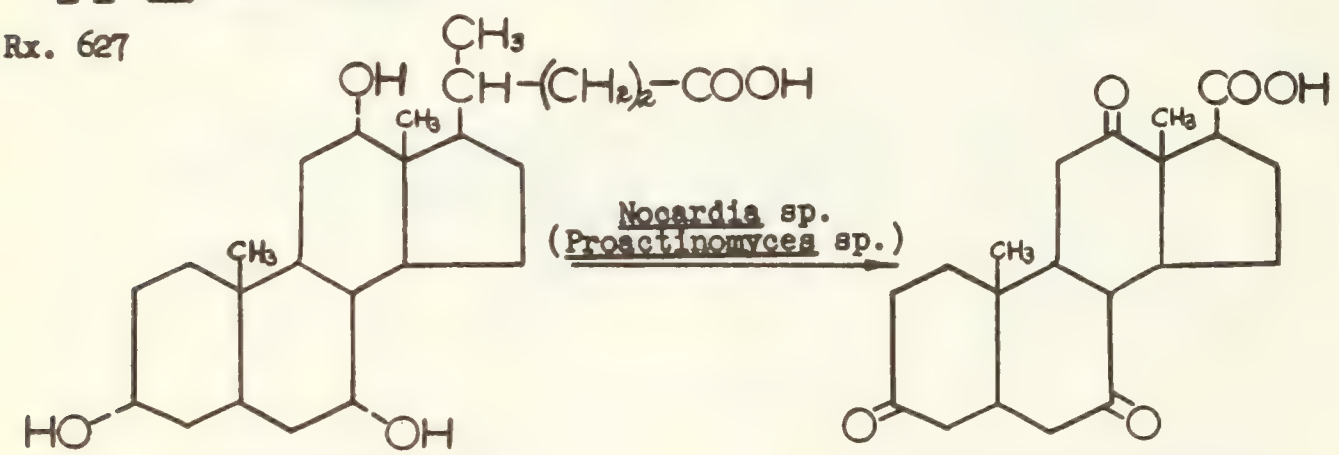
Δ^4-cholestenone

3-keto-Δ^4-etiocholenic acid

Turfitt, Biochem. J. 42, 376-83 (1948).

C.A. 42, 6406e (1948).

Rx. 627



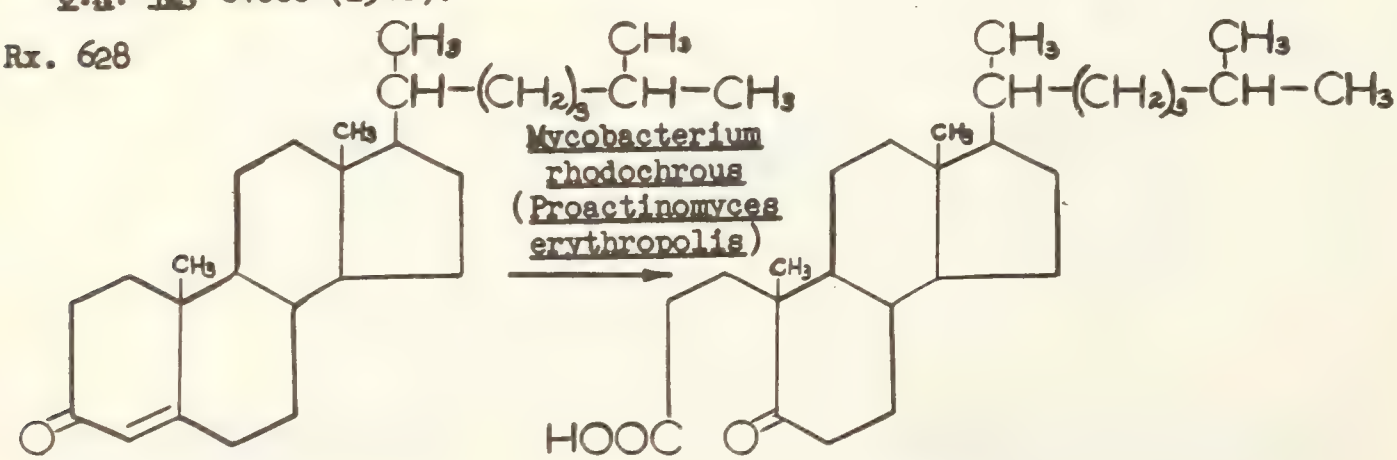
cholic acid

3,7,12-triketoetiocholanic acid

Turfitt, Biochem. J. 42, 376-83 (1948).

C.A. 42, 6406e (1948).

Rx. 628



Δ^4-cholestenone

Windaus' keto acid

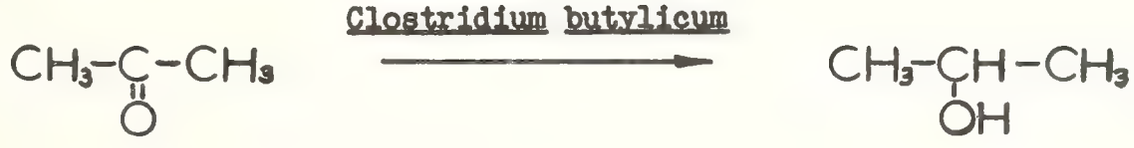
II. Reduction

a.

Langlykke and Fred, J. Bacteriol. 33, 102 (1937).

C.A. 31, 3095[1] (1937).

Rx. 629



acetone — 2-propanol

Färber et al., Biochem. Z. 112, 313-23 (1920).

C.A. 15, 1553[7] (1921).

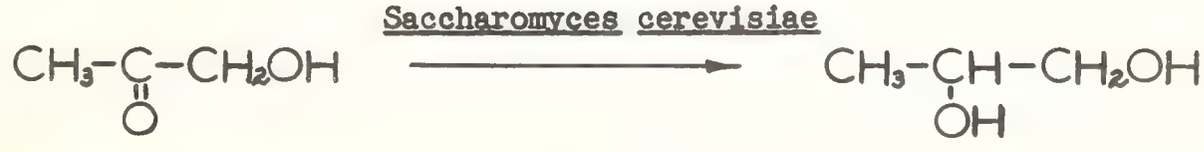
Rx. 630

acetol — ℓ-1,2-propanediol (55%)

Levene and Walti, Org. Syntheses 10, 84-6 (1930).

C.A. 24, 1843[2] (1930).

Rx. 631

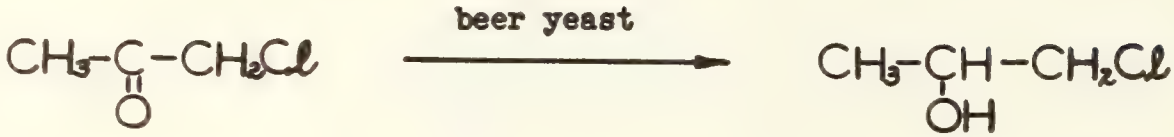


acetol — ℓ-1,2-propanediol (49-58%)

Sen, Quart. J. Indian Chem. Soc. 1, 1-8 (1924).

C.A. 19, 816[2] (1925).

Rx. 632



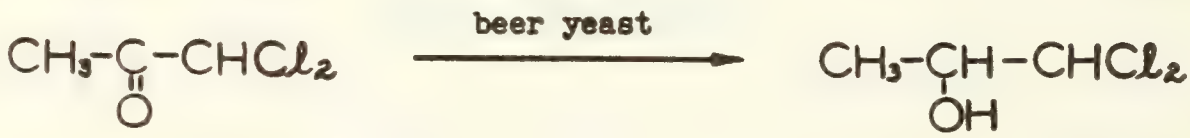
1-chloro-2-propanone (monochloroacetone)

1-chloro-2-propanol (25%)

Sen, Quart. J. Indian Chem. Soc. 1, 1-8 (1924).

C.A. 19, 816[2] (1925).

Rx. 633



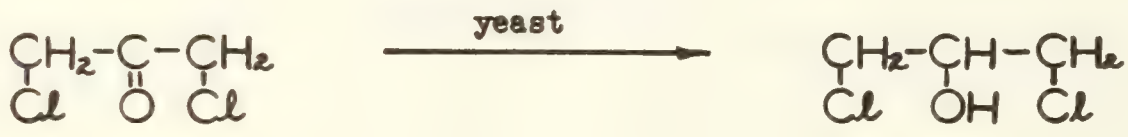
1,1-dichloro-2-propanone (α,α-dichloroacetone)

1,1-dichloro-2-propanol (54%)

Sen and Barat, Quart. J. Indian Chem. Soc. 2, 77-81 (1925).

C.A. 20, 50[8] (1926).

Rx. 634



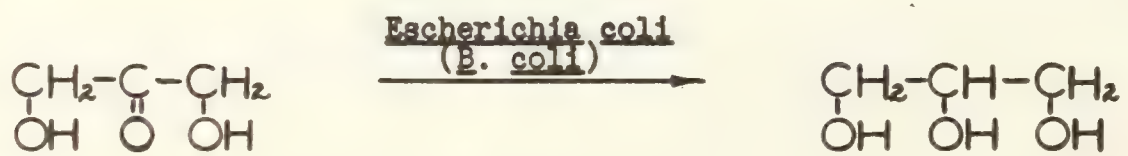
1,3-dichloro-2-propanone

1,3-dichloro-2-propanol (53%)

Virtanen et al., Z. physiol. Chem. 187, 7-44 (1930).

C.A. 24, 2157[3] (1930).

Rx. 635



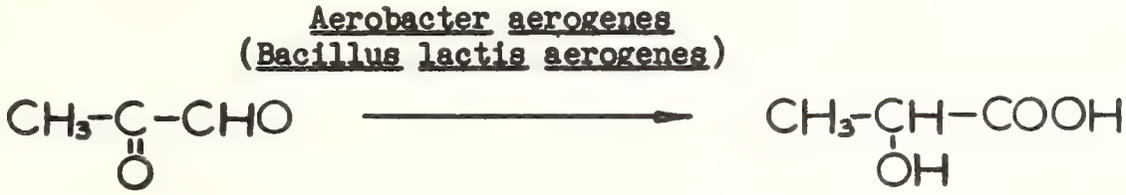
1,3-dihydroxyacetone

glycerol (50%)

Neuberg and Simon, Biochem. Z. 186, 331-6 (1927).

C.A. 21, 3646[5] (1927).

Rx. 636



methylglyoxal — d,l-lactic acid (100%)

Neuberg and Nord, Ber. 52B, 2237-48 (1919).

C.A. 14, 2190[6] (1920).

Rx. 637

2-butanone (methylethylketone) — d-2-butanol

Neuberg and Nord, Ber. 52B, 2248-54 (1919).

C.A. 14, 2191[3] (1920).

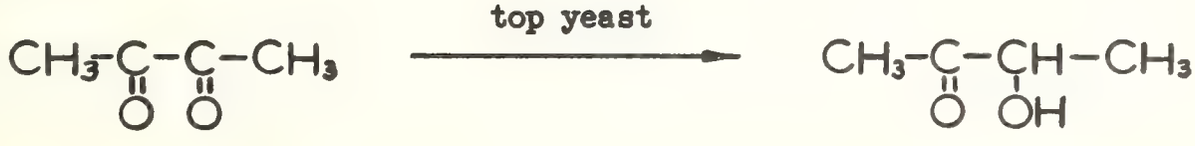
Rx. 638

diacetyl (2,3-butanedione) — 2,3-butanediol (α-butylene glycol)(35%)

Nagelschmidt, Biochem. Z. 186, 317-21 (1927).

C.A. 21, 3650[3] (1927).

Rx. 639

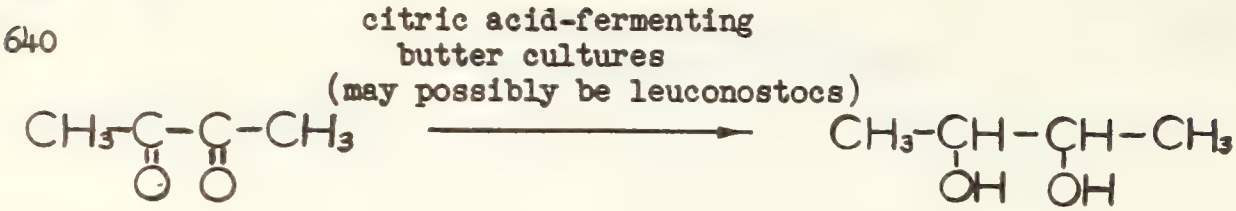


diacetyl — acetoin (acetylmethylcarbinol)

Hammer et al., Research Bull. 191, 381-407 (1935).

C.A. 30, 1134[6] (1936).

Rx. 640

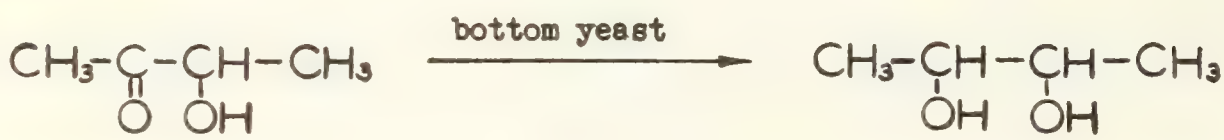


2,3-butanedione (diacetyl) → 2,3-butanediol (butylene glycol)

Neuberg and Kobel, Biochem. Z. 160, 250-5 (1925).

C.A. 20, 920[2] (1926).

Rx. 641

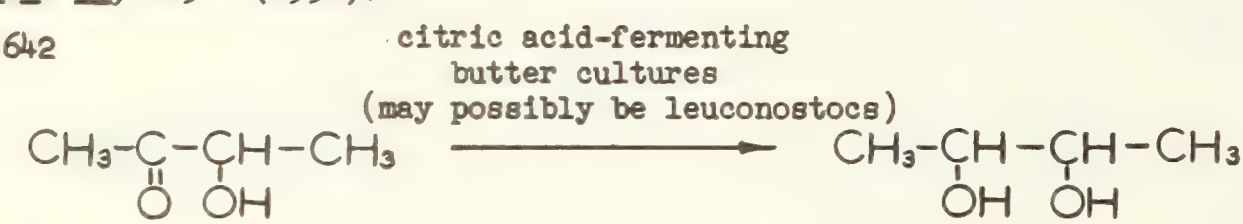


3-hydroxy-2-butanone (acetoin) → 2,3-butanediol (60%)

Hammer et al., Research Bull. 191, 381-407 (1935).

C.A. 30, 1134[6] (1936).

Rx. 642

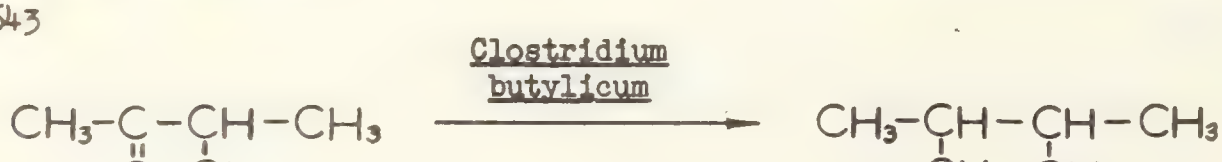


3-hydroxy-2-butanone → 2,3-butanediol

Langlykke and Fred, J. Bacteriol. 33, 102 (1937).

C.A. 31, 3095[1] (1937).

Rx. 643

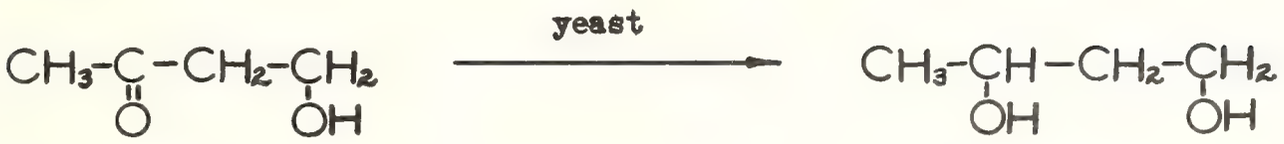


3-hydroxy-2-butanone → 2,3-butanediol

Levene and Walti, J. Biol. Chem. 94, 361-6 (1931).

C.A. 26, 1901[2] (1932).

Rx. 644

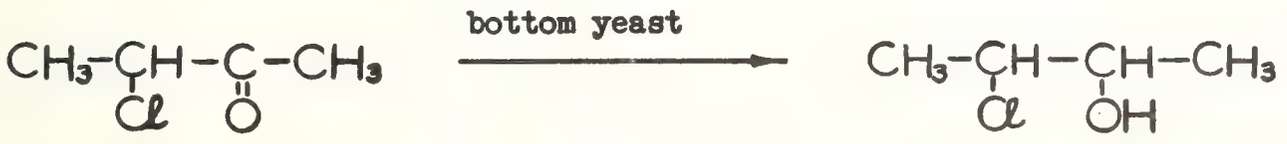


butanol-1-one-3 → l-1,3-butanediol

Santomauro, Biochem. Z. 151, 48-50 (1924).

C.A. 19, 1581[4] (1925).

Rx. 645

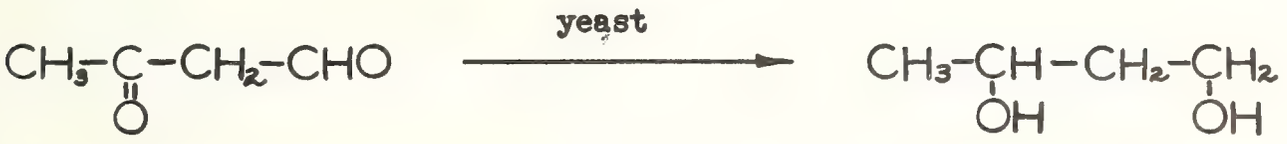


3-chloro-2-butanone → l-3-chloro-2-butanol

Grzycki, Biochem. Z. 265, 195-8 (1933).

C.A. 28, 189[6] (1934).

Rx. 646



β-ketobutyraldehyde → d-1,3-butanediol

Neuberg and Kerb, Biochem. Z. 61, 184-6 (1914).

C.A. 8, 1975[4] (1914).

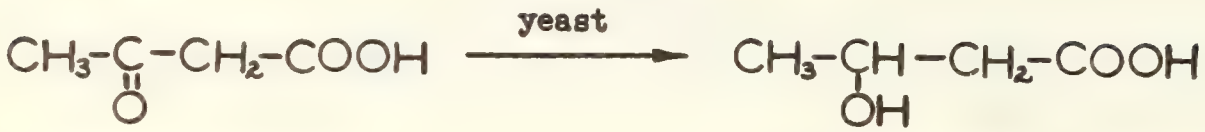
Rx. 647

α-ketobutyric acid → 1-propanol (66%)

Friedmann, Naturwissenschaften 19, 400 (1931).

C.A. 25, 5951[9] (1931).

Rx. 648

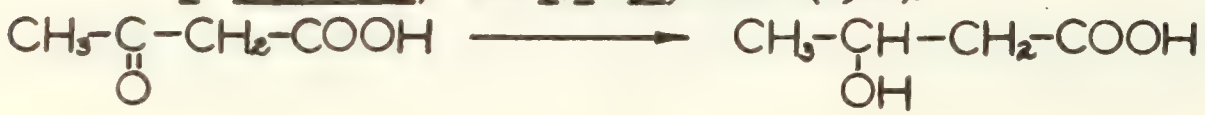


acetoacetic acid — d-β-hydroxybutyric acid (44-84%)

Heitzmann, Compt. rend. 214, 509-11 (1942).

C.A. 37, 2410[2] (1943).

Rx. 649 Bacillus M (an organism of the Bacillus subtilis group resembling B. megaterium). See C.A. 18, 1000[4] (1924).

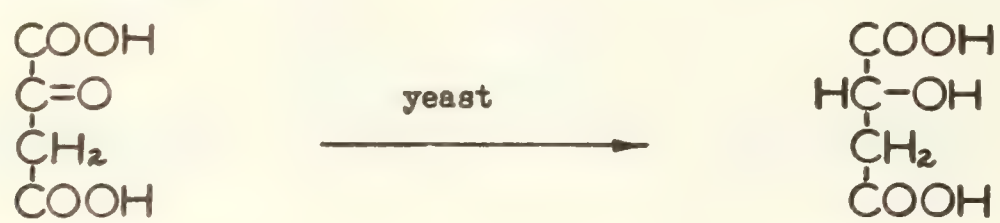


acetoacetic acid — β-hydroxybutyric acid

Neuberg and Gorr, Biochem. Z. 154, 495-502 (1924).

C.A. 19, 2683[1] (1925).

Rx. 650

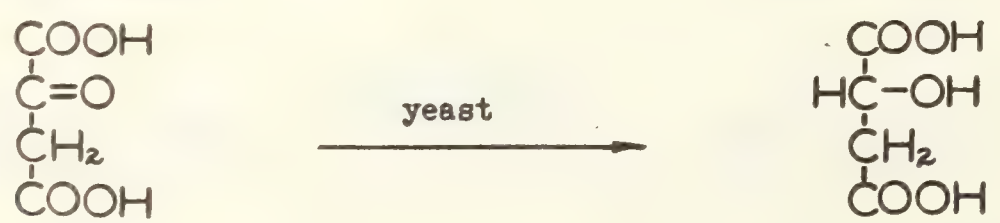


oxalacetic acid — malic acid

Fujise, Biochem. Z. 236, 231-6 (1931).

C.A. 25, 4898[2] (1931).

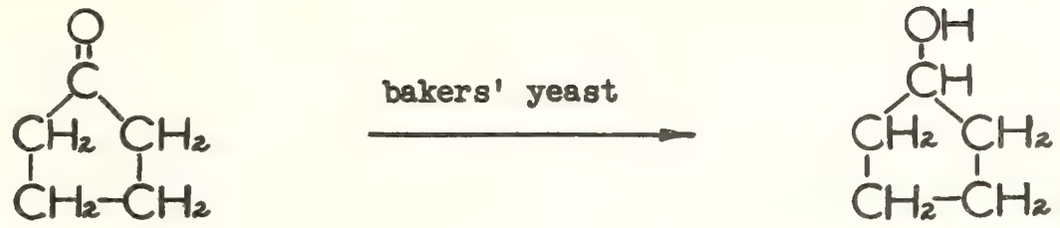
Rx. 651



oxalacetic acid (diethyl ester) — l-malic acid (18%)

Neuberg, Biochim. et Biophys. Acta 4, 170-8 (1950).
C.A. 44, 3669g (1950).

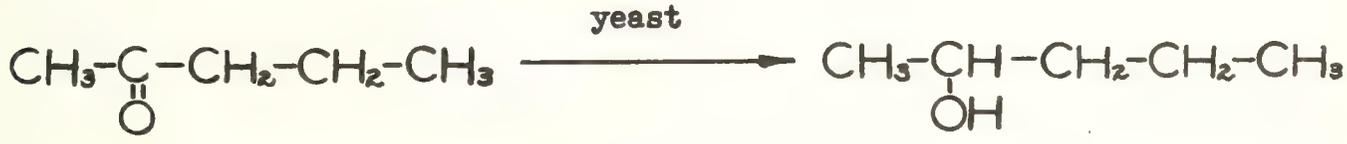
Rx. 652



cyclopentanone → cyclopentanol (42%)

Neuberg and Nord, Ber. 52B, 2237-48 (1919).
C.A. 14, 2190[6] (1920).

Rx. 653



2-pentanone (methyl-n-propylketone) → d-2-pentanol

Veibel and Bach, Kgl. Danske Videnskab. Selskab., Math.-fys. Medd. 13, 19pp. (1936).
C.A. 30, 5717[5] (1936).

Rx. 654

2,3-pentanedione (2,3-diketopentane) → d-2,3-pentanediol (67%)

Veibel and Bach, Kgl. Danske Videnskab. Selskab., Math.-fys. Medd. 13, 19pp. (1936).
C.A. 30, 5717[5] (1936).

Rx. 655

2,3-pentanedione → 2-hydroxy-3-pentanone (methylpropionylcarbionol)

Neuberg and Cahill, Enzymologia 1, 142-4 (1936).

C.A. 30, 7631[2] (1936).

Rx. 656

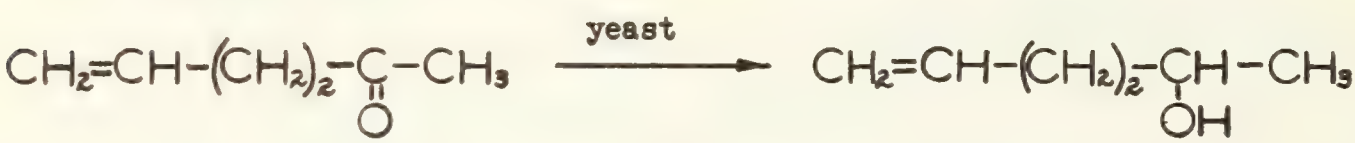
2,3,4-pentanetrione (triketopentane)

2,3,4-pentanetriol (2.4%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 657



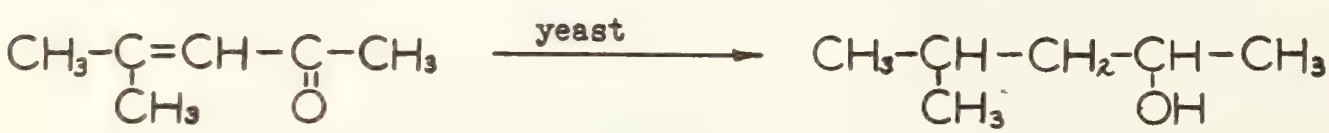
1-hexene-5-one

1-hexene-5-ol (80%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 658

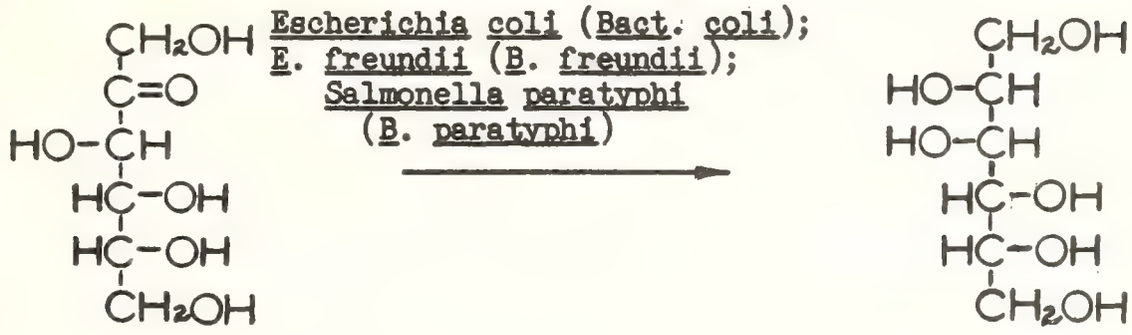


mesityl oxide

4-methyl-2-pentanol (6-11%)

Bolcato and Pasquini, Ind. saccar. ital. 32, 408-10 (1939).
C.A. 33, 7479^2 (1939).

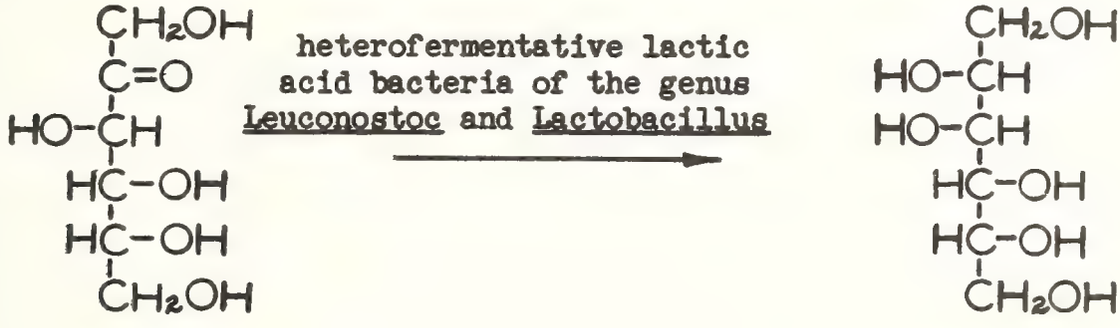
Rx. 659



fructose (from sucrose) → mannitol (93%)

Katagiri and Kitahara, Rept. Japan. Assoc. Advancement Sci. 16, 548-52(1942).
C.A. 44, 3089f (1950).

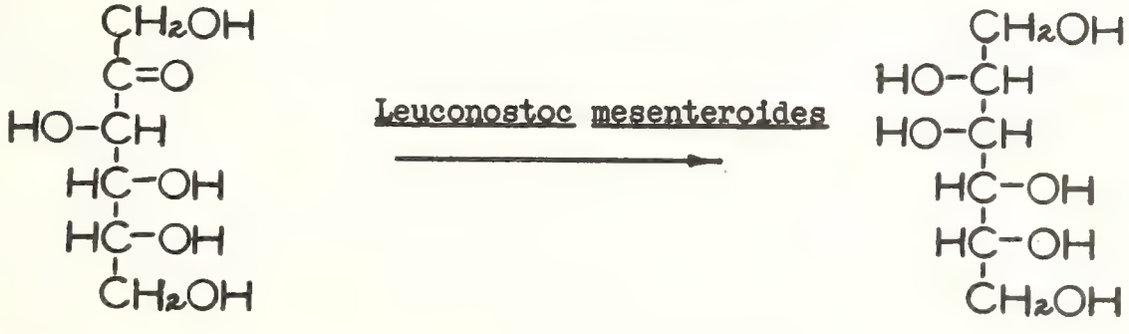
Rx. 660



fructose → mannitol

Blackwood and Blakley, Can. J. Microbiol. 2, 741-6 (1956).
C.A. 51, 2942b (1957).

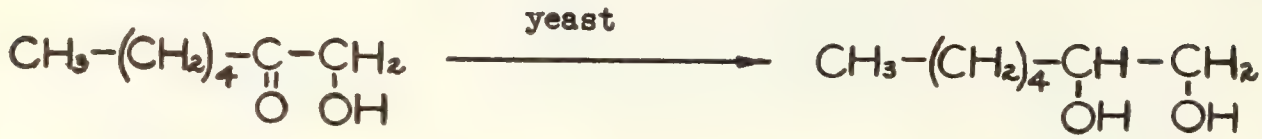
Rx. 661



fructose → mannitol (33%)

Levene and Walti, J. Biol. Chem. 98, 735-8 (1932).
C.A. 27, 1613[3] (1933).

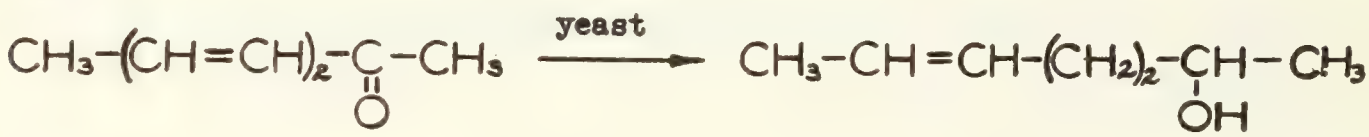
Rx. 662



1-hydroxy-2-heptanone — d-1,2-heptanediol

Fischer and Wiedemann, Ann. 520, 52-70 (1935).
C.A. 29, 7959[8] (1935).

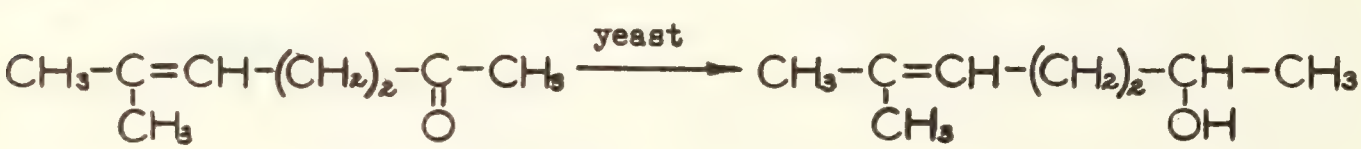
Rx. 663



3,5-heptadiene-2-one — 5-heptene-2-ol

Neuberg and Lewite, Biochem. Z. 91, 257-66 (1918).
C.A. 13, 2046[1] (1919).

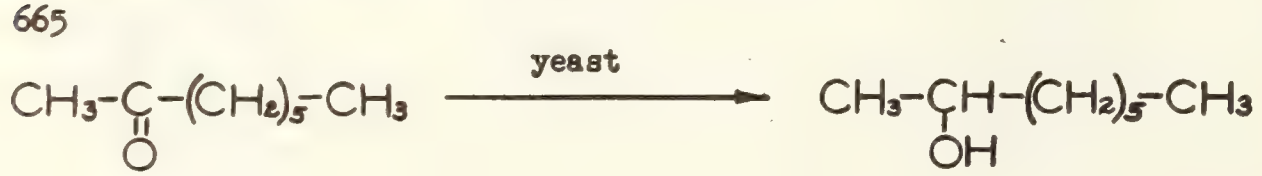
Rx. 664



6-methyl-5-heptene-2-one — 6-methyl-5-heptene-2-ol

Neuberg and Nord, Ber. 52B, 2237-48 (1919).
C.A. 14, 2190[6] (1920).

Rx. 665

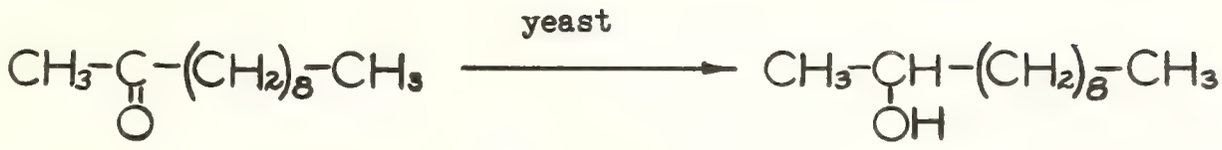


2-octanone — d-2-octanol

Neuberg and Nord, Ber. 52B, 2237-48 (1919).

C.A. 14, 2190[6] (1920).

Rx. 666

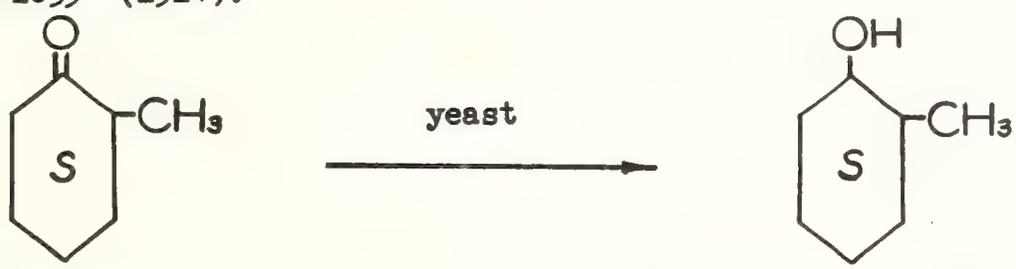


2-undecanone → d-2-undecanol

Akamatsu, Biochem. Z. 142, 188-90 (1923).

C.A. 18, 1839[5] (1924).

Rx. 667

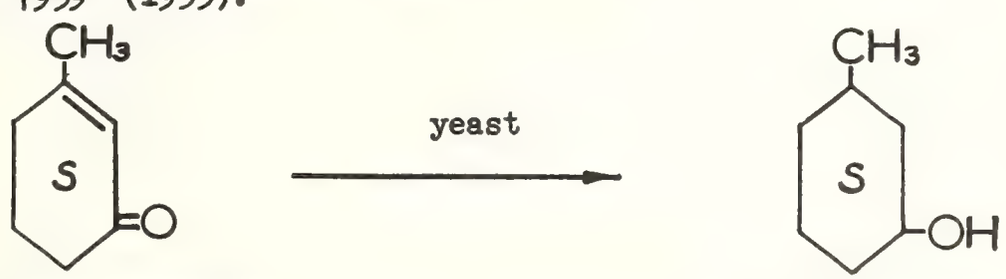


o-methylcyclohexanone → d-o-methylcyclohexanol (38%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 668

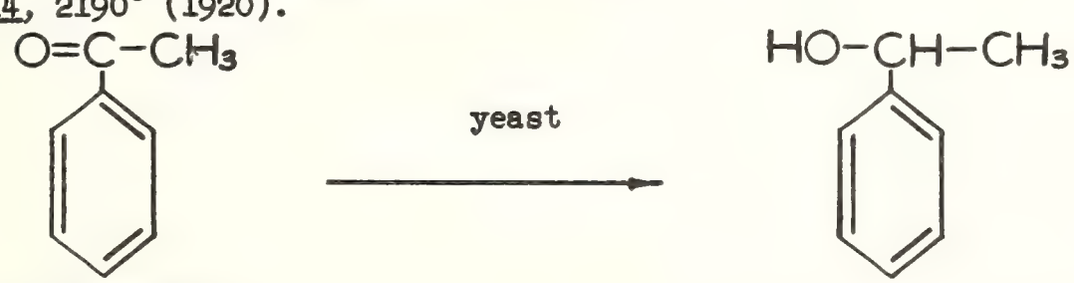


3-methyl-2-cyclohexenone → 3-methylcyclohexanol (20%)

Neuberg and Nord, Ber. 52B, 2237-48 (1919).

C.A. 14, 2190[6] (1920).

Rx. 669

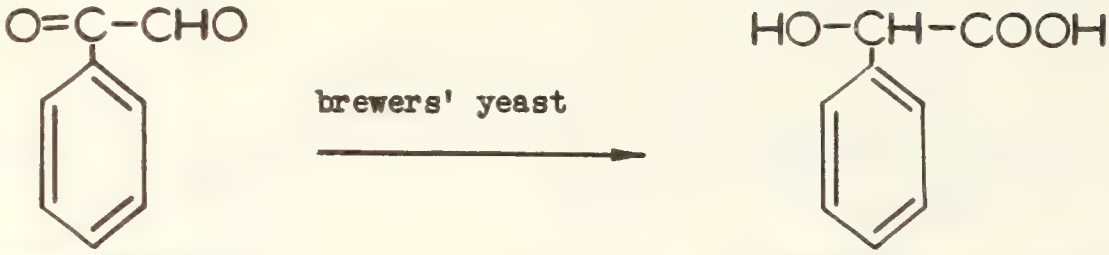


acetophenone (methylphenylketone) → l-1-phenylethanol

Dakin, J. Biol. Chem. 18, 91-3 (1914).

C.A. 8, 2737[8] (1914).

Rx. 670

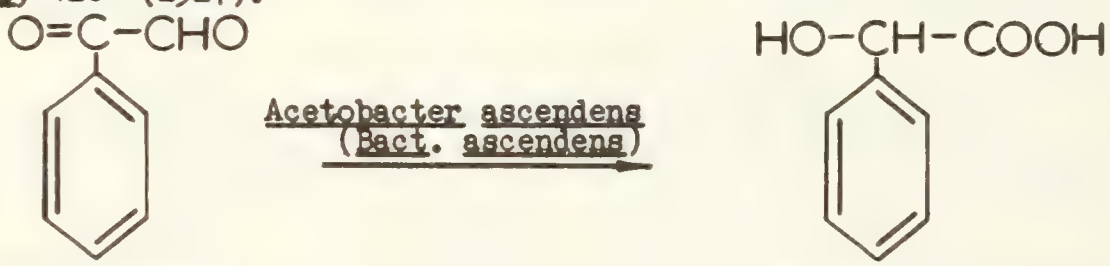


phenylglyoxal — l-mandelic acid (26%)

Mayer, Biochem. Z. 174, 420-4 (1926).

C.A. 21, 426[1] (1927).

Rx. 671

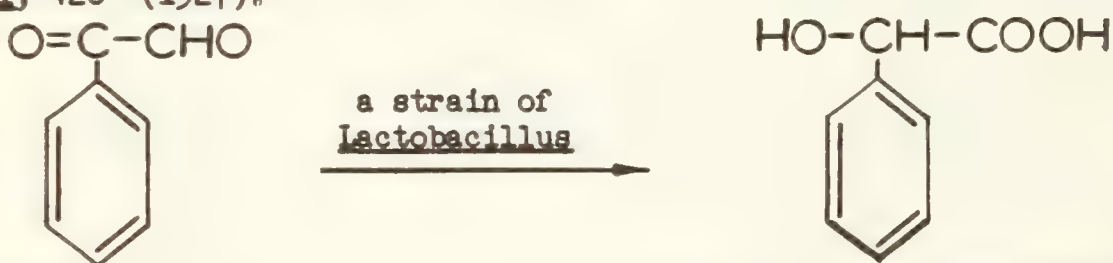


phenylglyoxal — mandelic acid (95%)

Mayer, Biochem. Z. 174, 420-4 (1926).

C.A. 21, 426[1] (1927).

Rx. 672

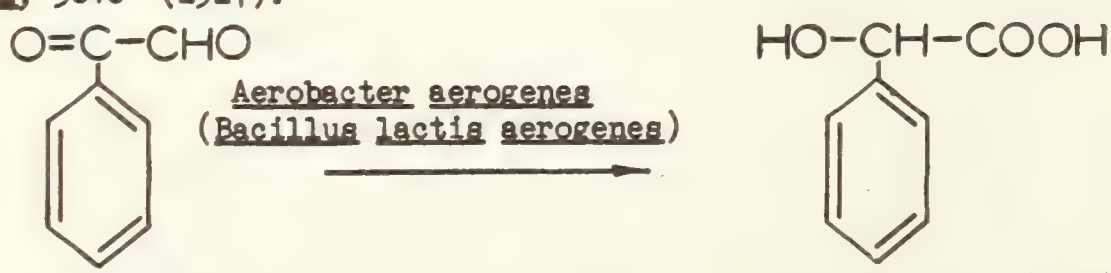


phenylglyoxal — d-mandelic acid (96%)
(l-product obtained with dried cells)

Neuberg and Simon, Biochem Z. 186, 331-6 (1927).

C.A. 21, 3646[5] (1927).

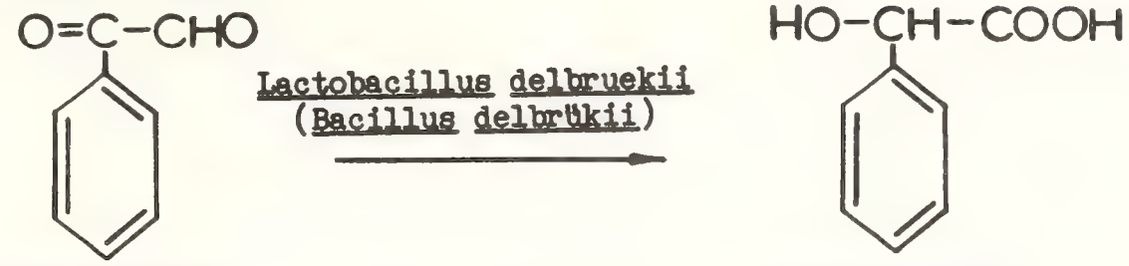
Rx. 673



phenylglyoxal — mandelic acid (100%)

Neuberg and Simon, Biochem. Z. 186, 331-6 (1927).
C.A. 21, 3646[5] (1927).

Rx. 674



phenylglyoxal — mandelic acid

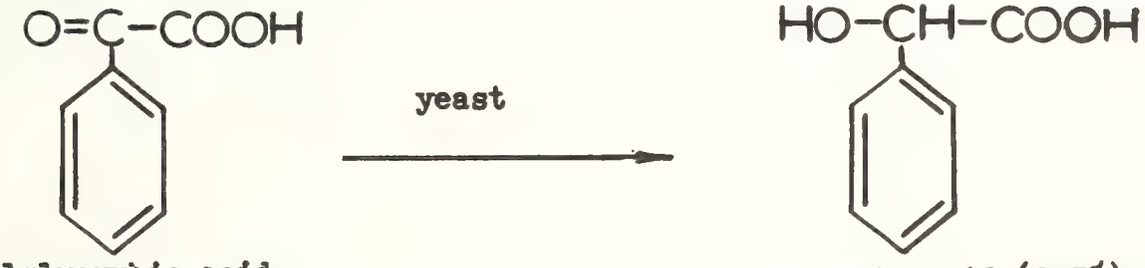
Fischer and Wiedemann, Ann. 520, 52-70 (1935).
C.A. 29, 7959[8] (1935).

Rx. 675

furfuralacetone — 4-furyl-2-butanol

Neubauer and Fromherz, Z. physiol. Chem. 70, 326-50 (1911).
C.A. 5, 1789[6] (1911).

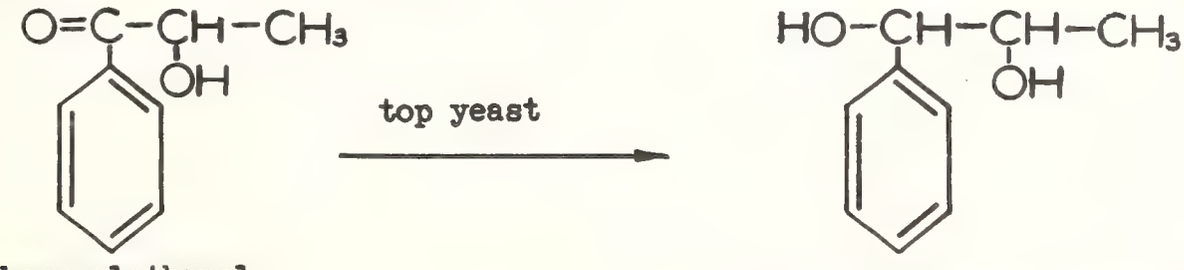
Rx. 676



phenylglyoxylic acid — mandelic acid (2.5%)

Neuberg and Komarewsky, Biochem. Z. 182, 285-90 (1927).
C.A. 21, 2289[8] (1927).

Rx. 677

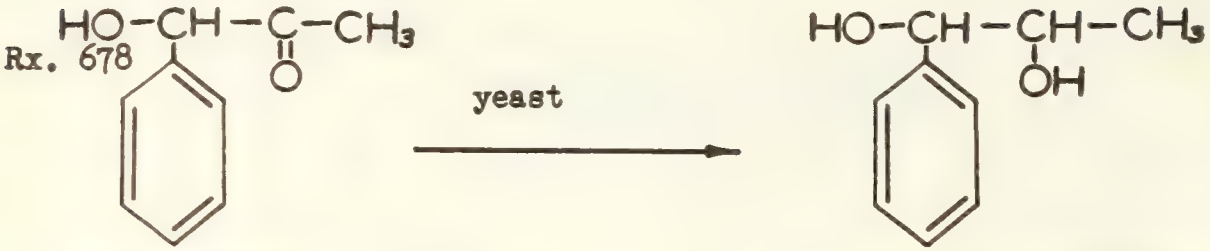


1-benzoylethanol — l-1-phenyl-1,2-propanediol

Shimazu, J. Chem. Soc. Japan 71, 503-5 (1950).

C.A. 45, 9004d (1951).

Rx. 678

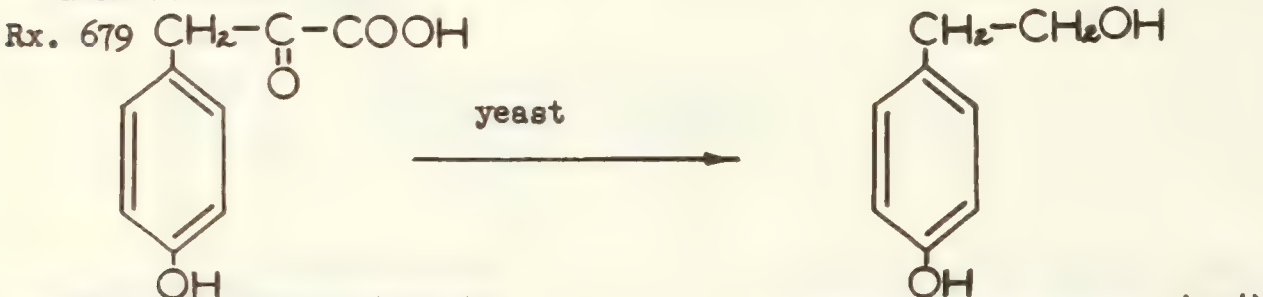


1-phenyl-2-keto-1-propanol → 1-phenyl-1,2-propanediol

Neubauer and Fromherz, Z. physiol. Chem. 70, 326-50 (1911).

C.A. 5, 1789[6] (1911).

Rx. 679

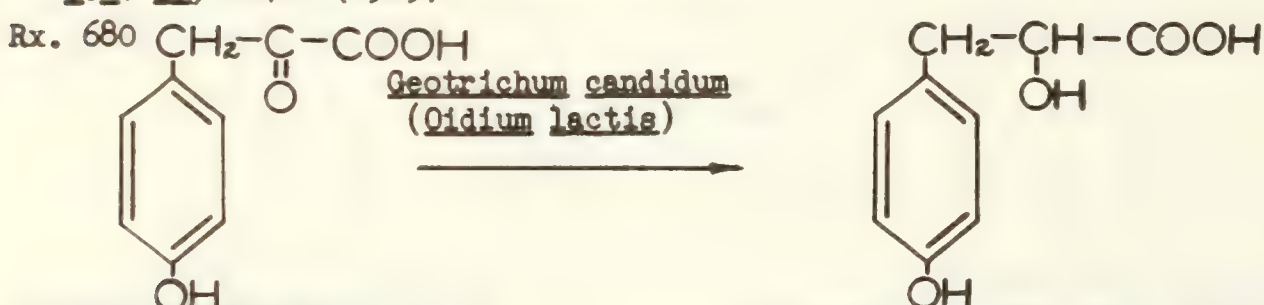


p-hydroxyphenylpyruvic acid → p-hydroxyphenylethanol (32%)

Kotake et al., Z. physiol. Chem. 143, 218-28 (1925).

C.A. 19, 1878[5] (1925).

Rx. 680

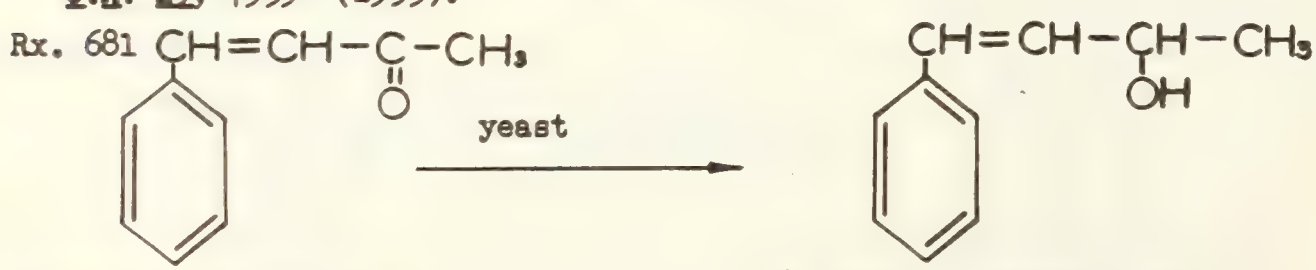


p-hydroxyphenylpyruvic acid → d-p-hydroxyphenyllactic acid

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 681



4-phenyl-3-butene-2-one (benzalacetone) → 4-phenyl-3-butene-2-ol

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 682

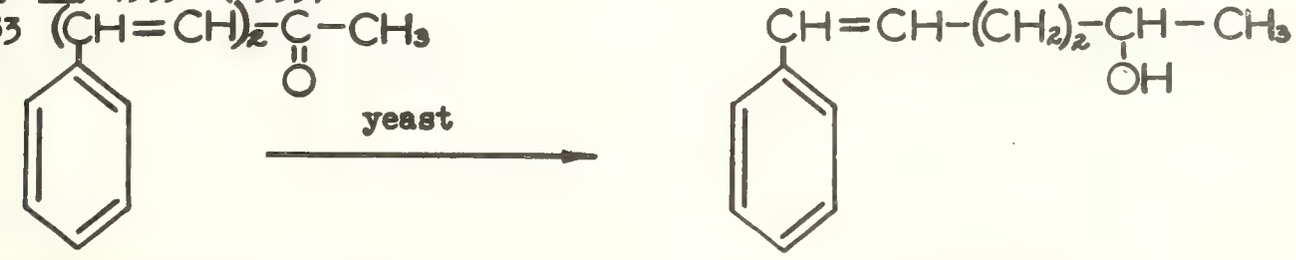
4-phenyl-3-butene-2-one

4-phenyl-2-butanol

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 683



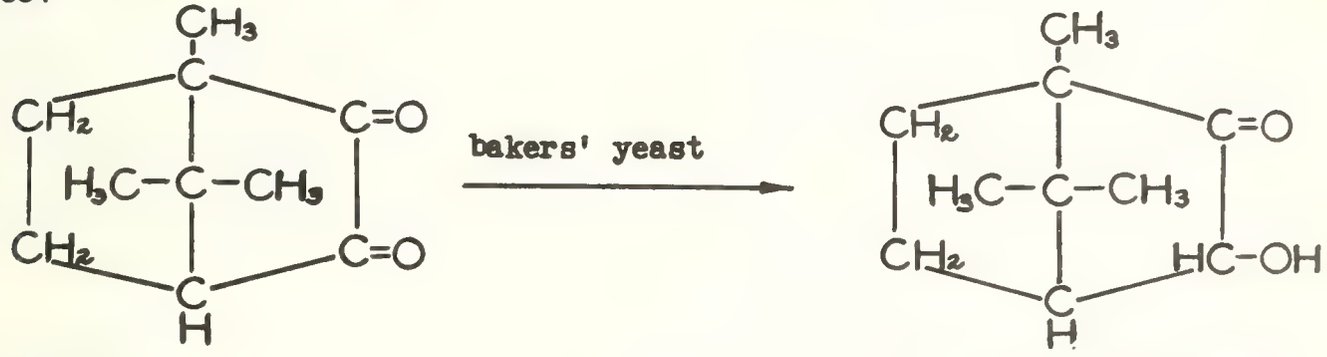
6-phenyl-3,5-hexadiene-2-one

6-phenyl-5-hexene-2-ol

Neuberg, Biochim. et Biophys. Acta 4, 170-8 (1950). See Adv. Carbohyd. Chem. 4, p. 89 (1949).

C.A. 44, 3669g (1950).

Rx. 684



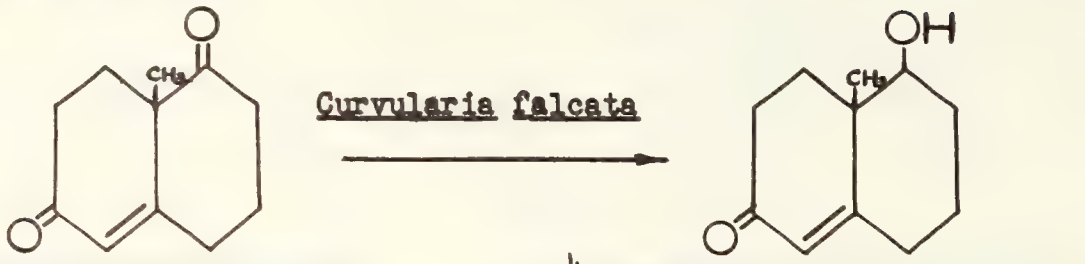
2,3-diketocamphane

3-hydroxycamphor (63%)

Prelog and Acklin, Helv. Chim. Acta 39, 748-57 (1956).

C.A. 50, 16726e (1956).

Rx. 685



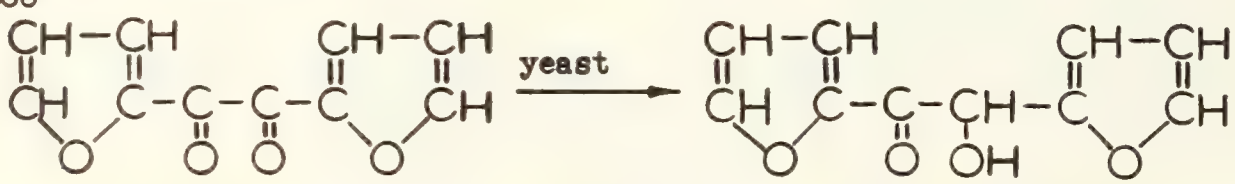
Δ^4-9-methyloctaline-3,8-dione → Δ^4-9-methyloctaline-8-ol-3-one

---

Neuberg et al., Arch. Biochem. 1, 391-5 (1943).

C.A. 37, 2758[5] (1943).

Rx. 686

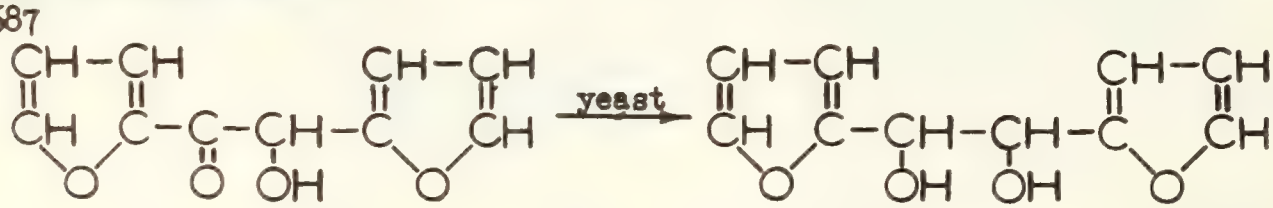


furil → furoin (approx. 10%)

Neuberg et al., Arch. Biochem. 1, 391-5 (1943).

C.A. 37, 2758[5] (1943).

Rx. 687

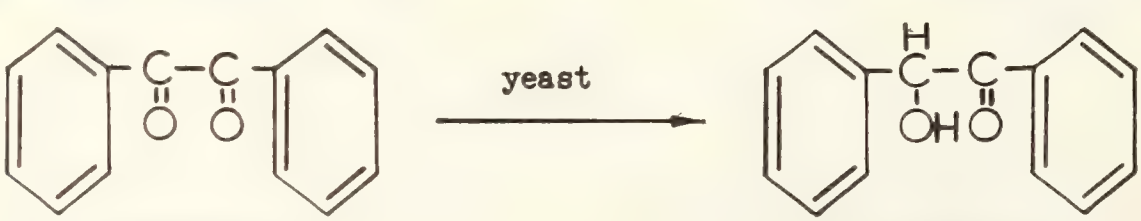


d,l-furoin → l-hydrofuroin

Neuberg and Nord, Ber. 52B, 2248-54 (1919).

C.A. 14, 2191[3] (1920).

Rx. 688

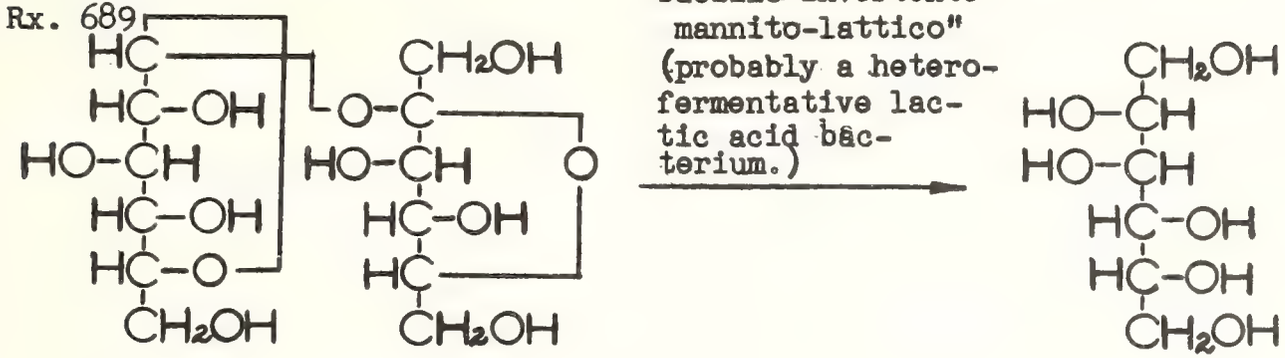


benzil → benzoin

Mezzadroli and Marsigli, Zymologica 2 [5/6], 101-21 (1925).

C.A. 20, 2913[8] (1926).

Rx. 689



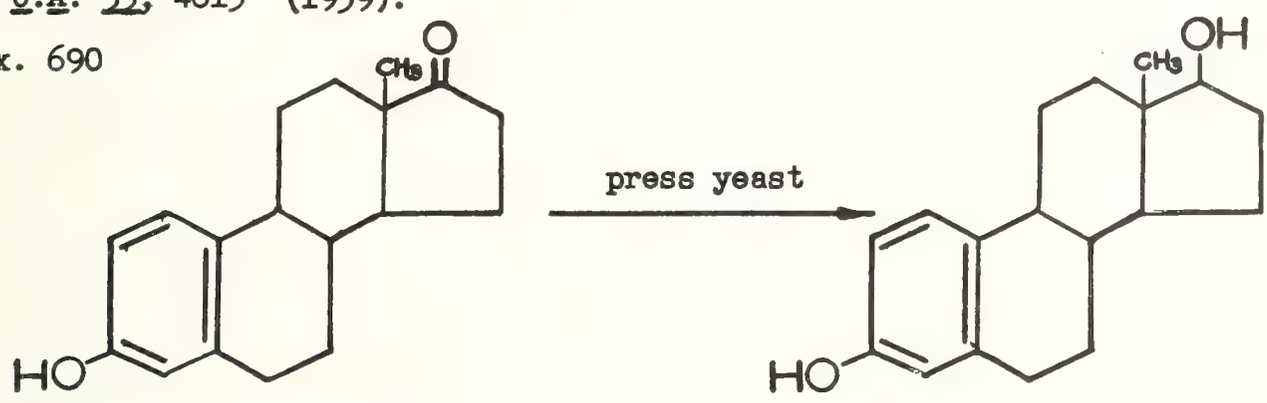
sucrose

mannitol (18.7%)

Wettstein, Helv. Chim. Acta 22, 250-2 (1939).

C.A. 33, 4613[3] (1939).

Rx. 690



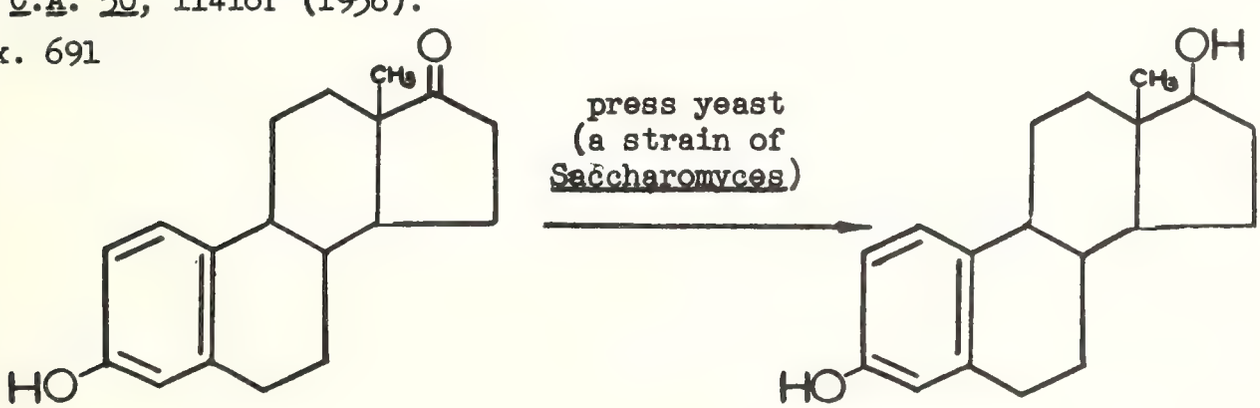
estrone

α-estradiol (70%)

Vischer et al., Experientia 12, 50-2 (1956).

C.A. 50, 11418f (1956).

Rx. 691

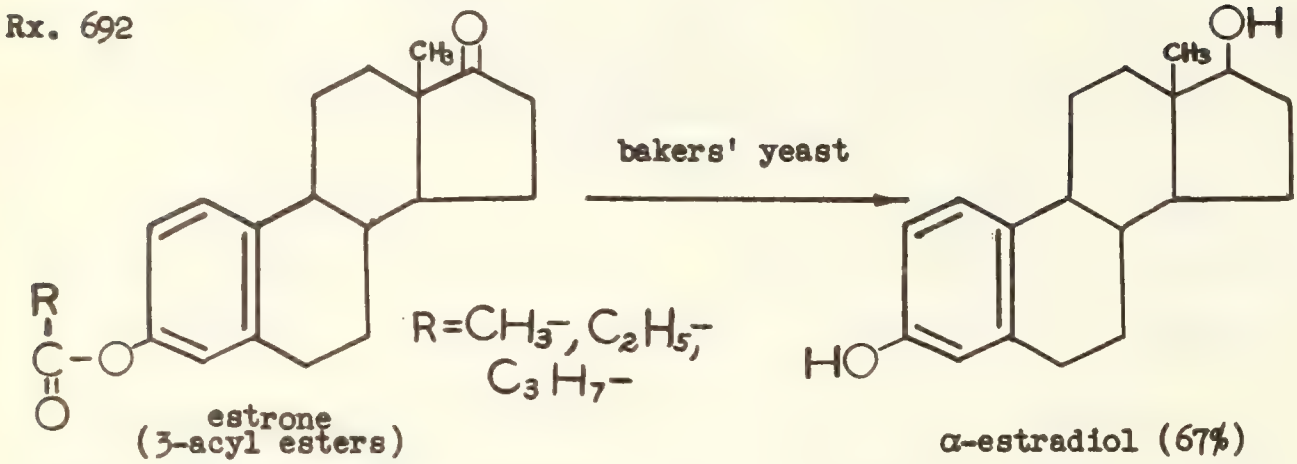


d,l-estrone

d-estradiol

Mamoli, Ber. 71B, 2696-8 (1938).
C.A. 33, 2156[8] (1939).

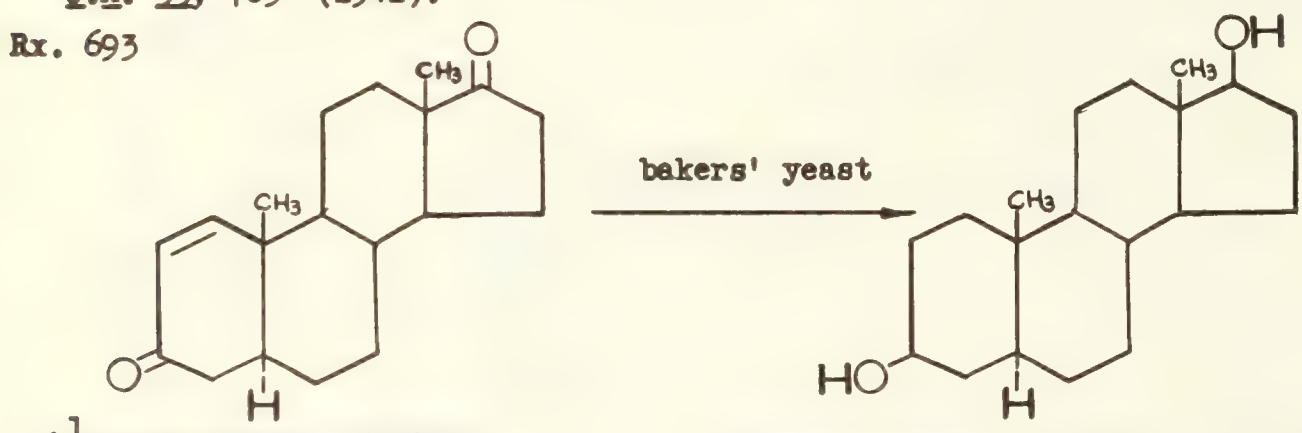
Rx. 692



estrone (3-acyl esters) → α-estradiol (67%)

Butenandt et al., Ber. 73B, 818-20 (1940).
C.A. 35, 763[9] (1941).

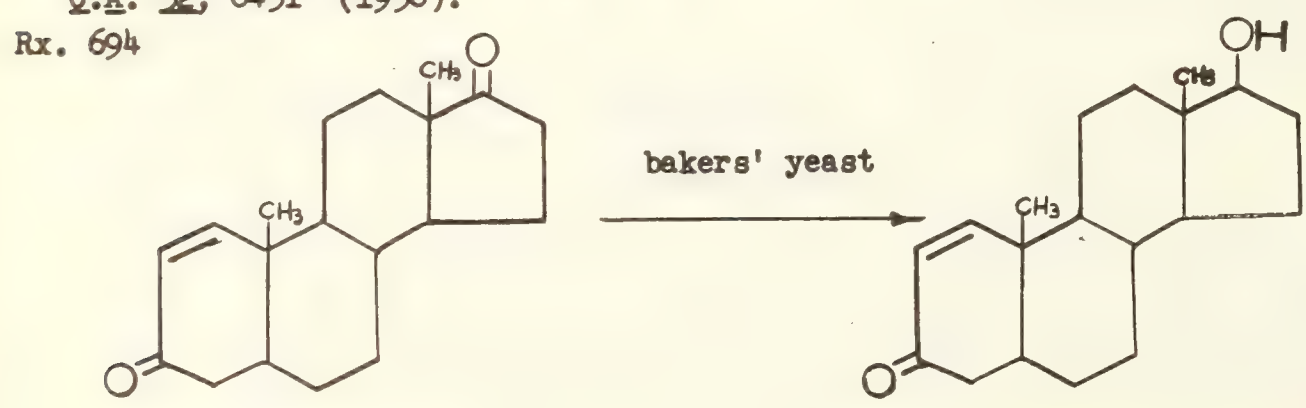
Rx. 693



Δ[1]-androstene-3,17-dione → isoandrostane-3β,17β-diol (approx. 25%)

Butenandt and Dannenberg, Ber. 71B, 1681-5 (1938).
C.A. 32, 8431[3] (1938).

Rx. 694

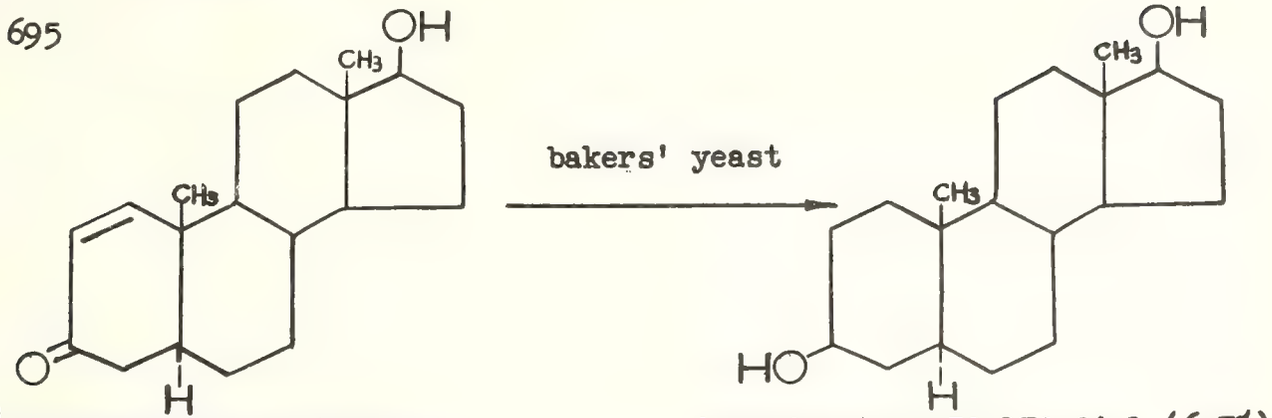


Δ[1]-androstene-3,17-dione → Δ[1]-androstene-17β-ol-3-one (83%)

Butenandt et al., Ber. 73B, 818-20 (1940).

C.A. 35, 7639 (1941).

Rx. 695



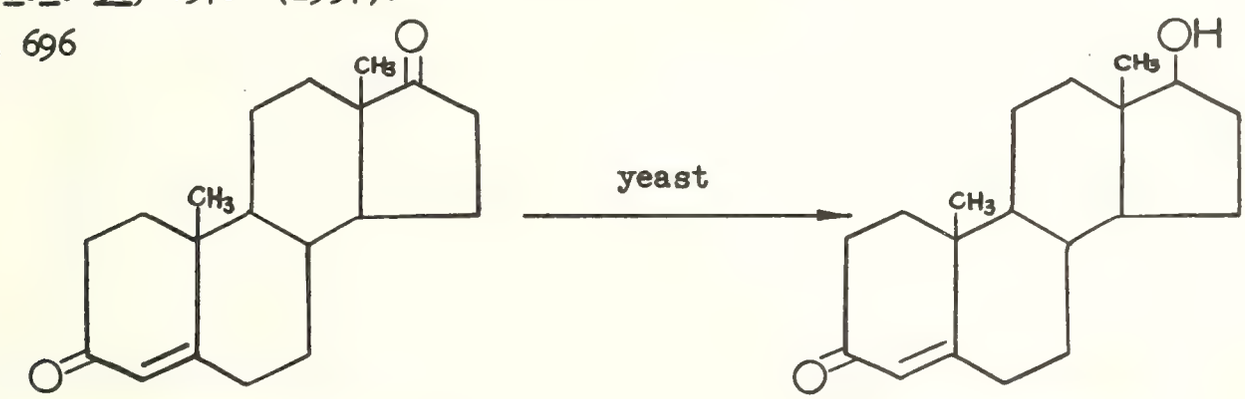
Δ^1-androstene-17β-ol-3-one

isoandrostane-3β,17β-diol (6.7%)

Mamoli and Vercellone, Ber. 70B, 470-1 (1937).

C.A. 31, 43782 (1937).

Rx. 696



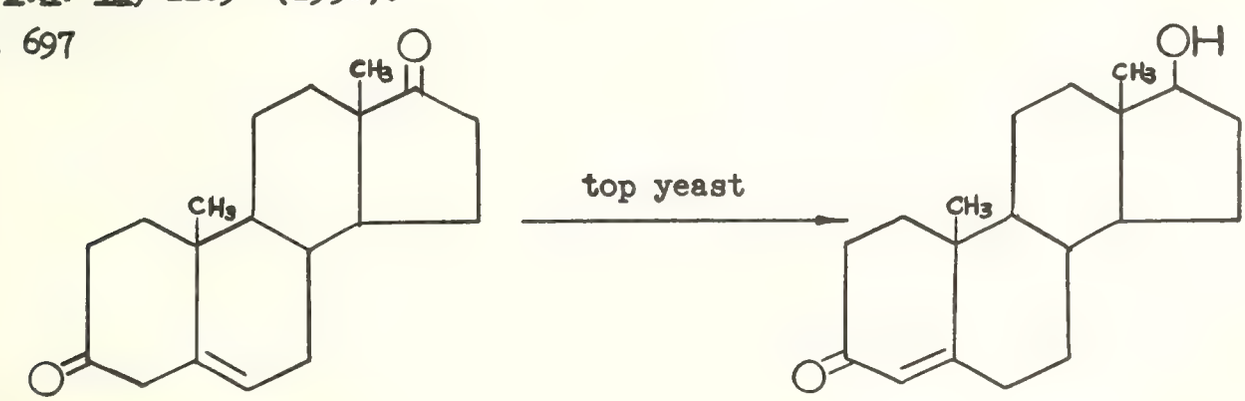
Δ^4-androstene-3,17-dione

testosterone

Mamoli and Vercellone, Ber. 70B, 2079-82 (1937).

C.A. 32, 21891 (1938).

Rx. 697



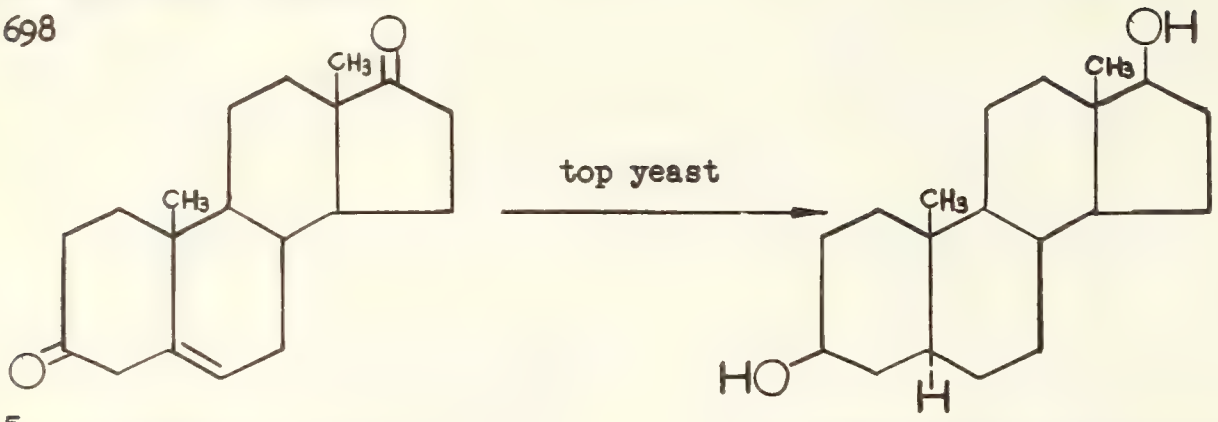
Δ^5-androstene-3,17-dione

testosterone

Mamoli and Vercellone, Ber. 70B, 2079-82 (1937).

C.A. 32, 2189[1] (1938).

Rx. 698

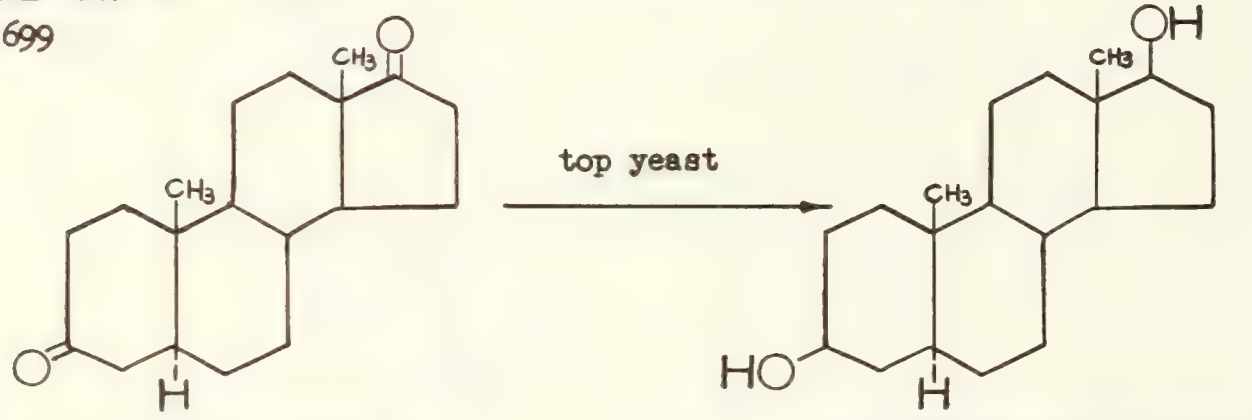


Δ^5-androstene-3,17-dione — isoandrostane-3β,17β-diol

Vercellone and Mamoli, Z. physiol. Chem. 248, 277-9 (1937).

C.A. 31, 7900[2] (1937).

Rx. 699

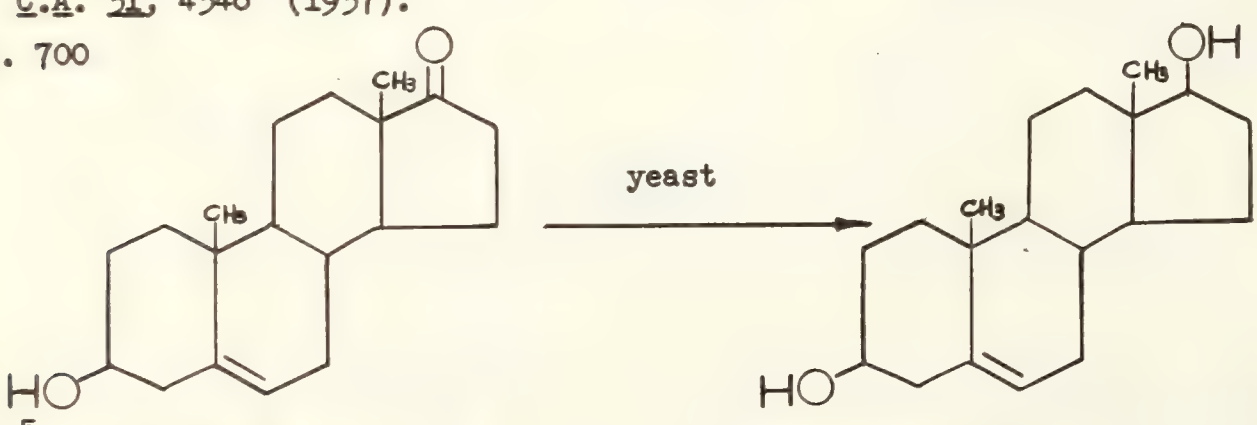


androstane-3,17-dione — isoandrostane-3β,17β-diol

Mamoli and Vercellone, Z. physiol. Chem. 245, 93-5 (1937).

C.A. 31, 4348[5] (1937).

Rx. 700

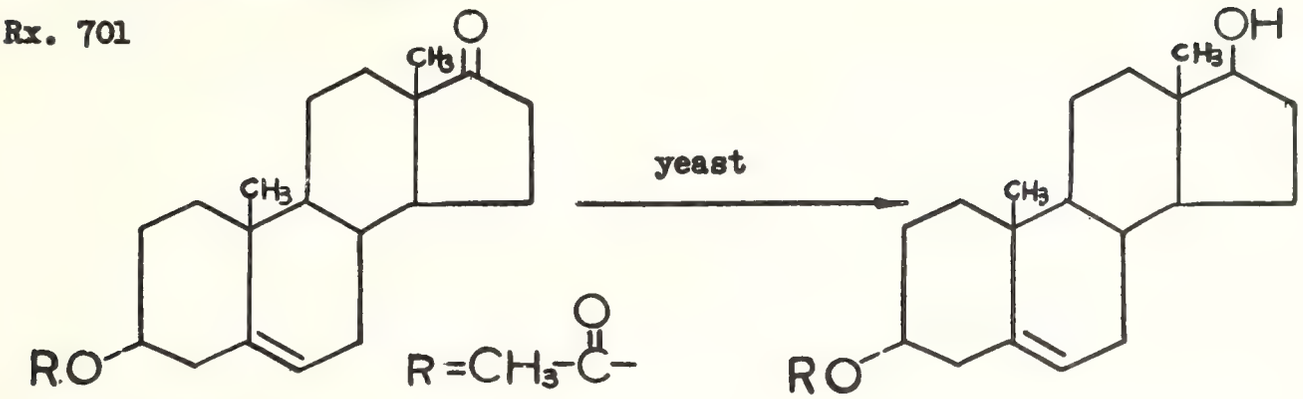


Δ^5-androstene-3β-ol-17-one (epidehydroandrosterone) — Δ^5-androstene-3β,17β-diol (approx. 18%)

Mamoli, Ber. 71B, 2696-8 (1938).

C.A. 33, 2156[8] (1939).

Rx. 701



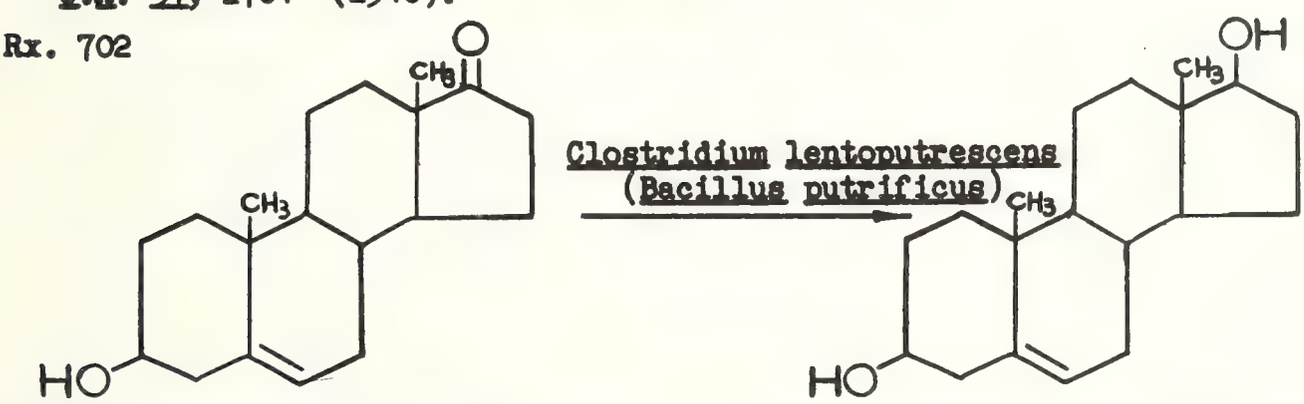
3-O-acetyl-Δ^5-androstene-3α-ol-17-one (dehydroandrosterone acetate)

3-O-acetyl-Δ^5-androstene-3α,17β-diol

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 1704[9] (1940).

Rx. 702



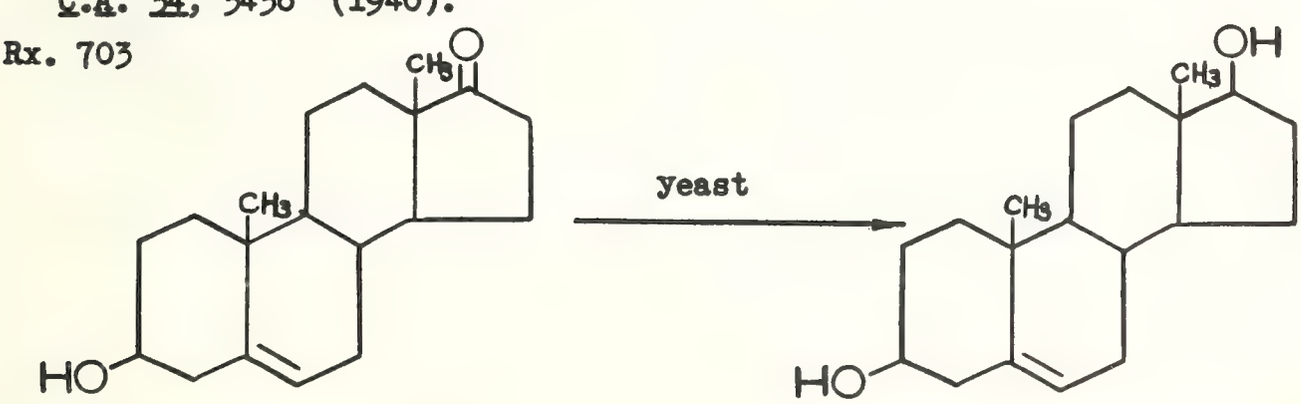
Δ^5-androstene-3β-ol-17-one (epidehydroandrosterone)

Δ^5-androstene-3β,17β-diol (approx.67%

Mamoli, U.S. 2,186,906 (Jan. 9, 1940).

C.A. 34, 3436[8] (1940).

Rx. 703



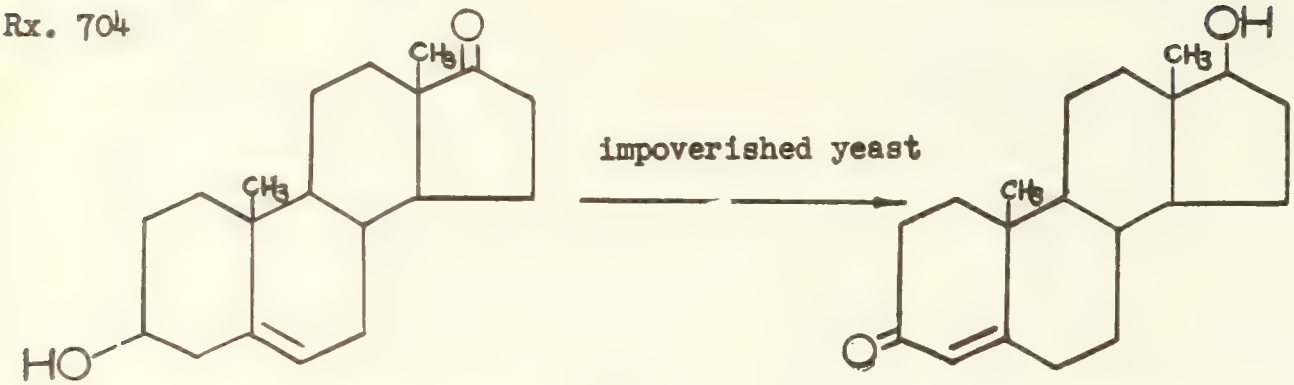
Δ^5-androstene-3β-ol-17-one

Δ^5-androstene-3β,17β-diol

Koester et al., U.S. 2,236,574 (April 1, 1941).

C. A. 35, 4393[4] (1941).

Rx. 704

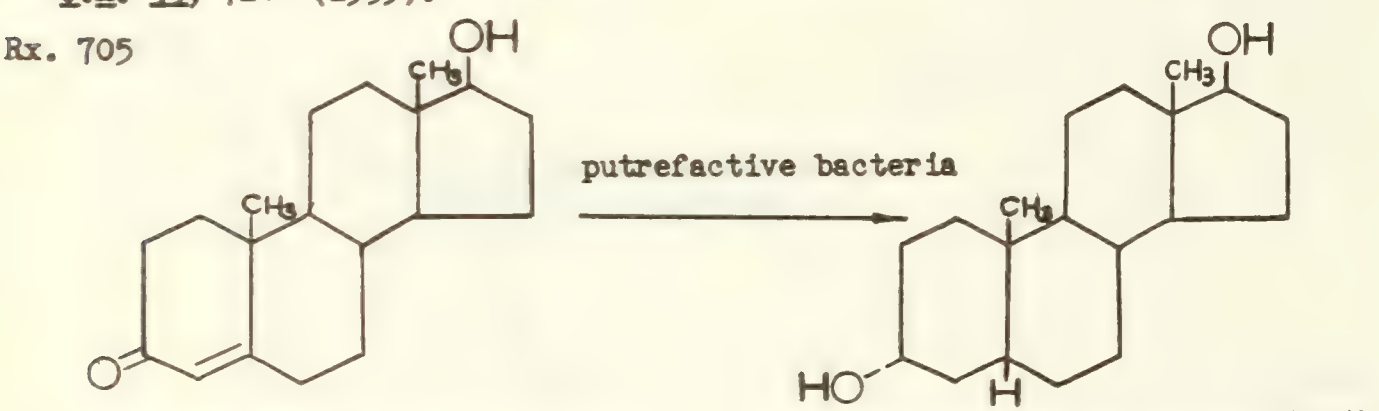


Δ^5-androstene-3α-ol-17-one → testosterone

Mamoli and Schramm, Ber. 71B, 2083-6 (1938).

C.A. 33, 7146 (1939).

Rx. 705

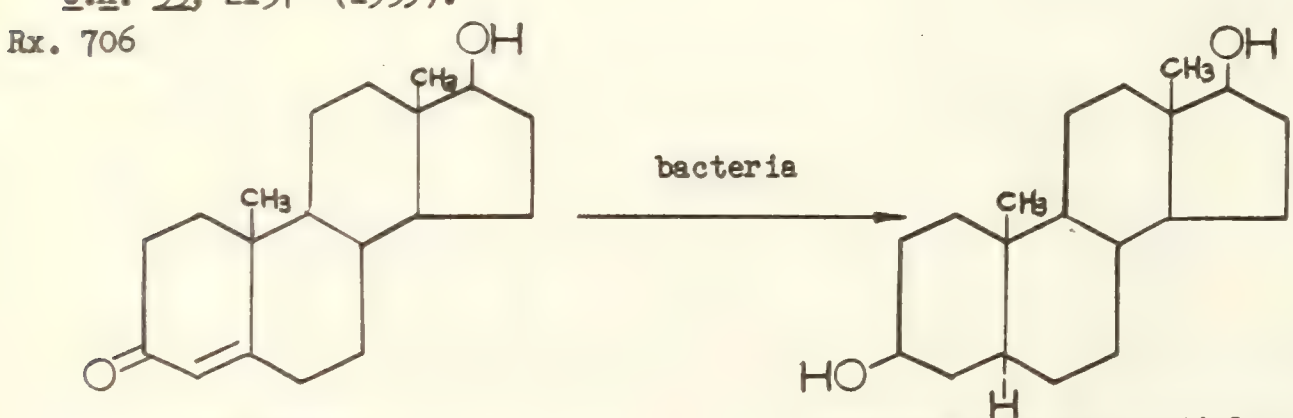


testosterone → epietiocholane-3α,17β-diol (60%)

Mamoli and Schramm, Ber. 71B, 2698-2701 (1938).

C.A. 33, 21571 (1939).

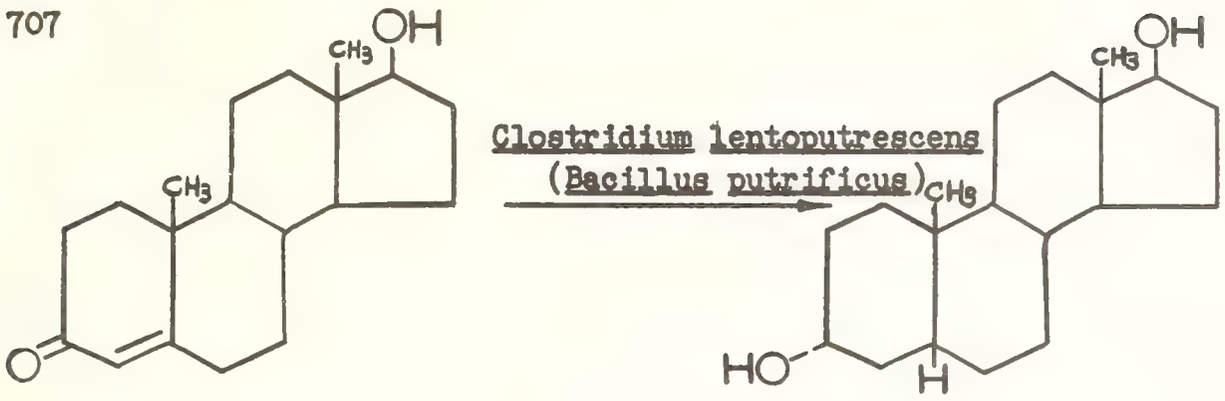
Rx. 706



testosterone → isoandrostane-3β,17β-diol (approx. 14%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).
C.A. 34, 1704[9] (1940).

Rx. 707

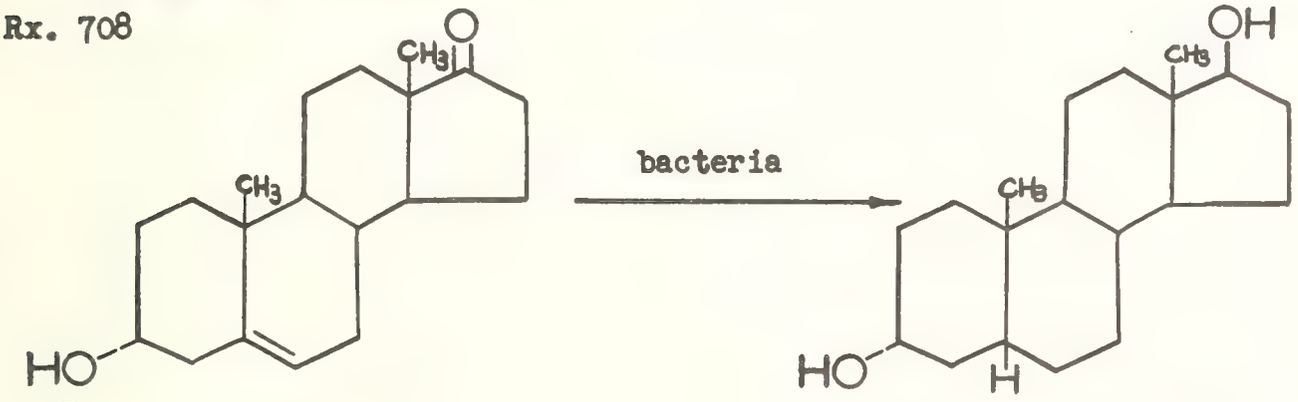


testosterone

epietiocholane-3α,17β-diol (approx. 10%)

Schramm and Mamoli, Ber. 71B, 1322-3 (1938).
C.A. 32, 7987[3] (1938).

Rx. 708

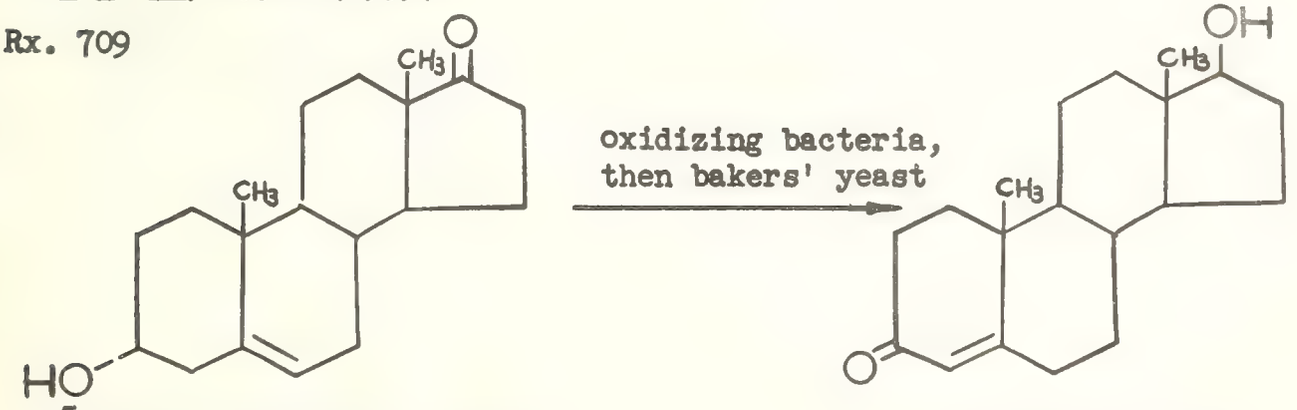


Δ[5]-androstene-3α-ol (dehydroandrosterone)

epietiocholane-3α,17β-diol

Mamoli, Ber. 71B, 2278-80 (1938).
C.A. 33, 1352[8] (1939).

Rx. 709

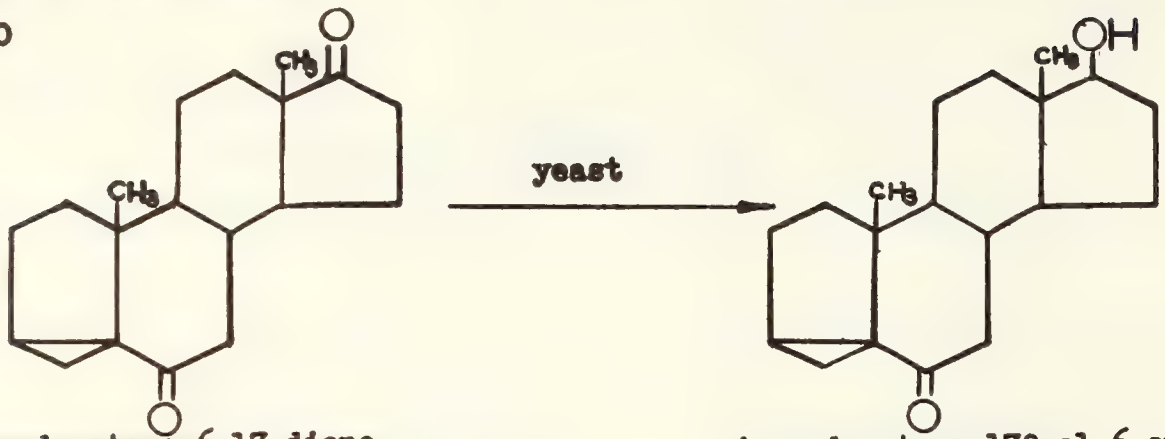


Δ[5]-androstene-3α-ol-17-one

testosterone (81%)

Butenandt and Suranyi, Ber. 75B, 591-7 (1942).
C.A. 37, 3444[4] (1943).

Rx. 710

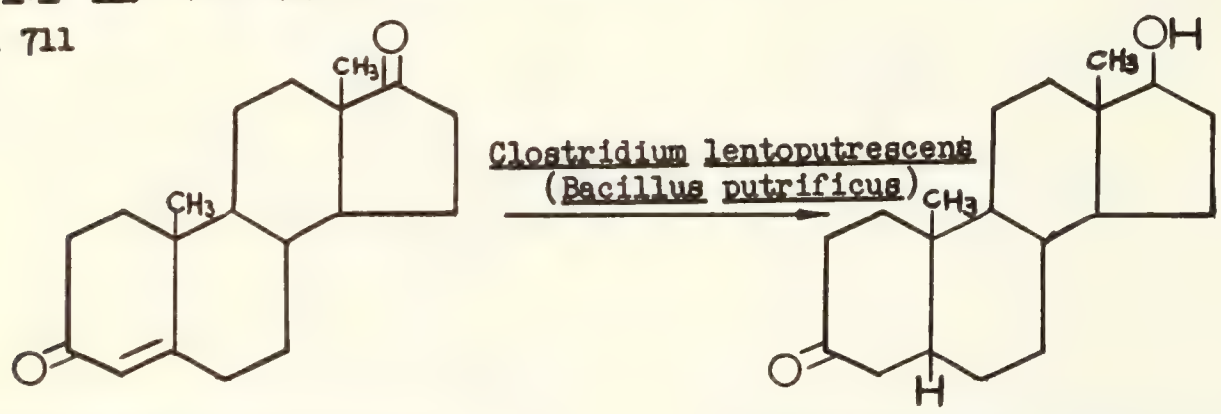


isoandrostane-6,17-dione

isoandrostane-17β-ol-6-one (approx. 50%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).
C.A. 34, 1704[9] (1940).

Rx. 711

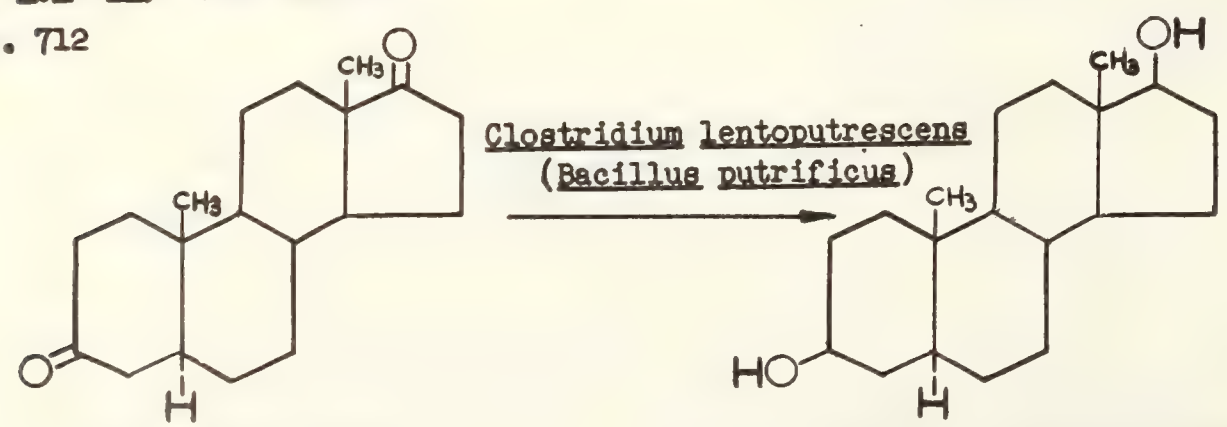


Δ^4-androstene-3,17-dione

etiocholane-17β-ol-3-one (39.5%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).
C.A. 34, 1704[9] (1940).

Rx. 712



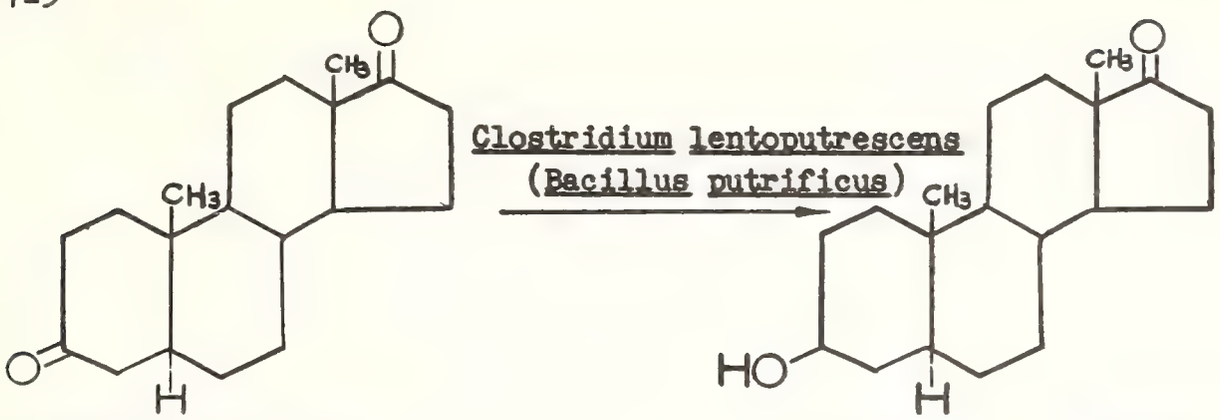
androstane-3,17-dione

isoandrostane-3β,17β-diol (35.5%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 17049 (1940).

Rx. 713



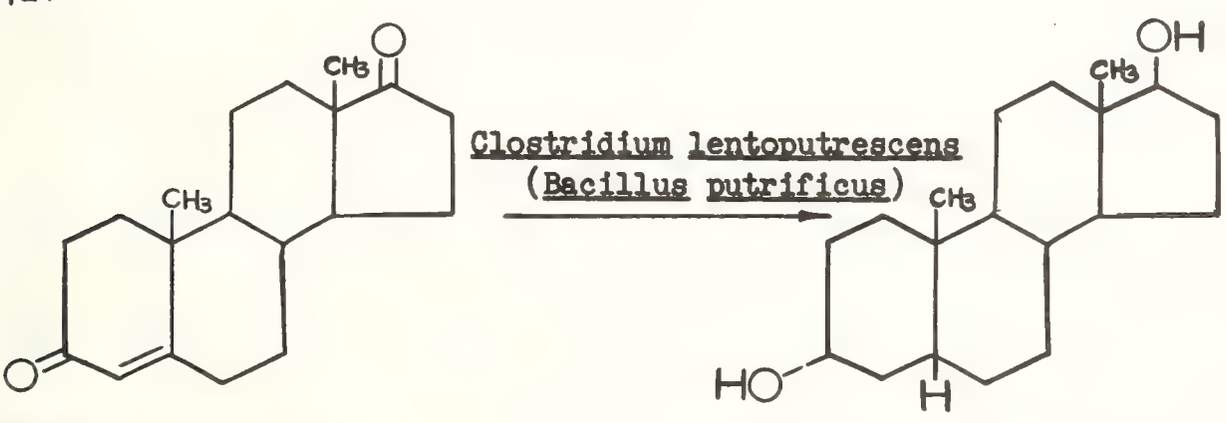
androstane-3,17-dione

isoandrosterone (36.4%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 17049 (1940).

Rx. 714



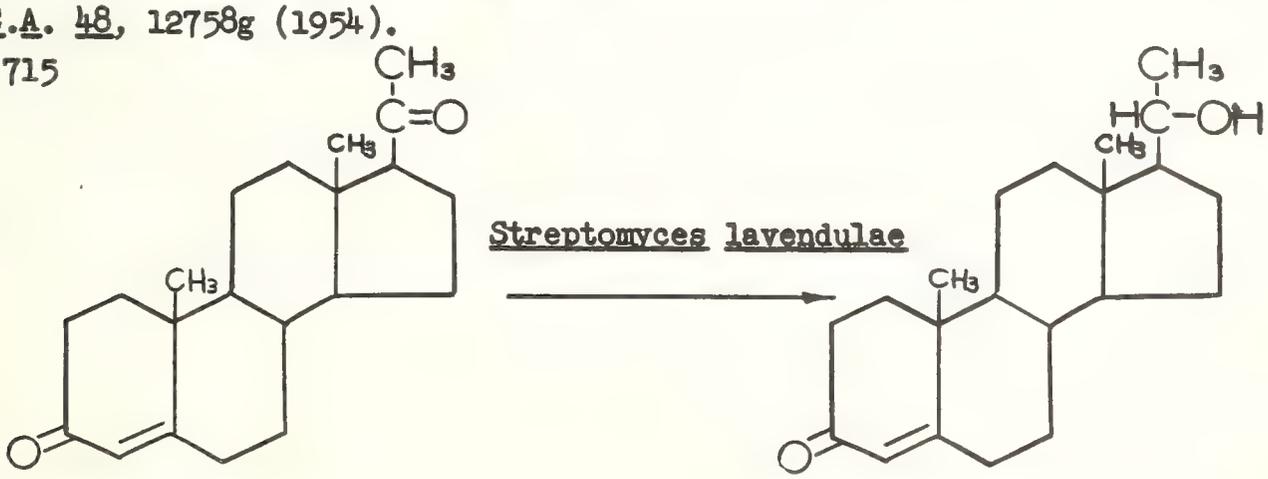
Δ^4-androstene-3,17-dione

epietiocholane-3α,17β-diol
(approx. 13%)

Fried et al., J. Am. Chem. Soc. 75, 5764-5 (1953).

C.A. 48, 12758g (1954).

Rx. 715



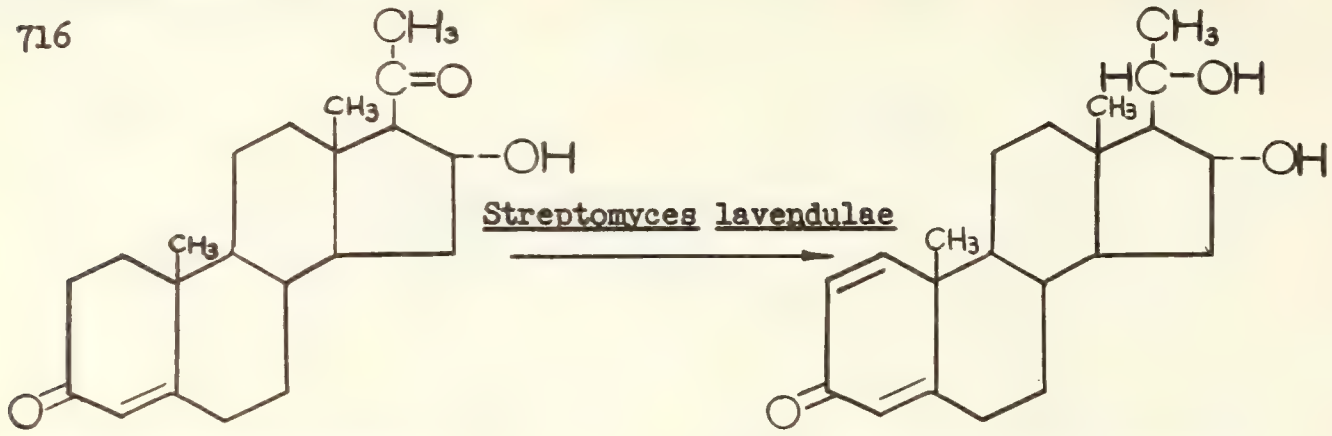
progesterone

Δ^4-pregnene-20β-ol-3-one

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 716



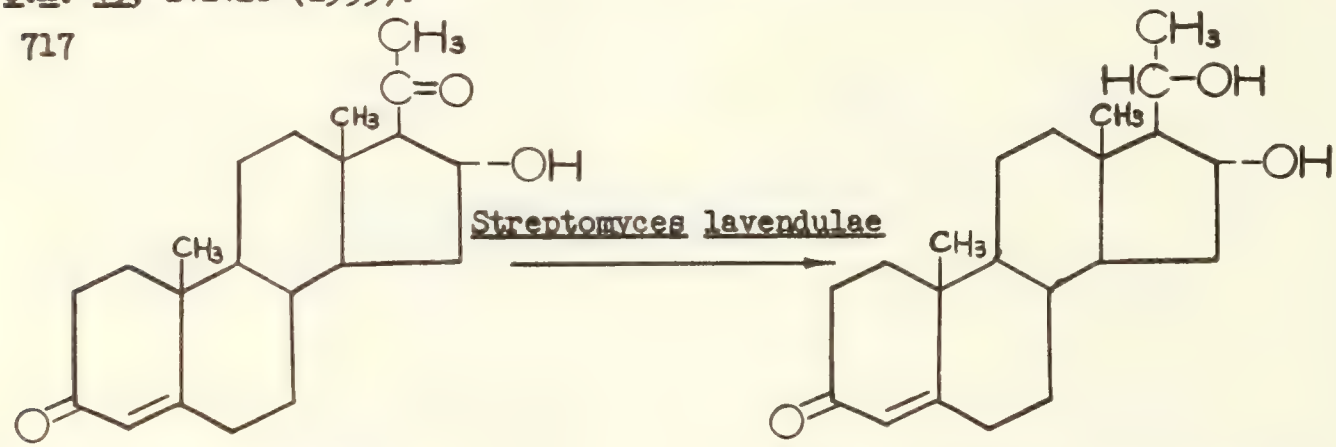
16α-hydroxyprogesterone

$\Delta^{1,4}$-pregnadiene-16α,20β-diol-3-one

Fried et al., Recent Progr. Hormone Research 11, 149-81 (1955).

C.A. 49, 14141b (1955).

Rx. 717



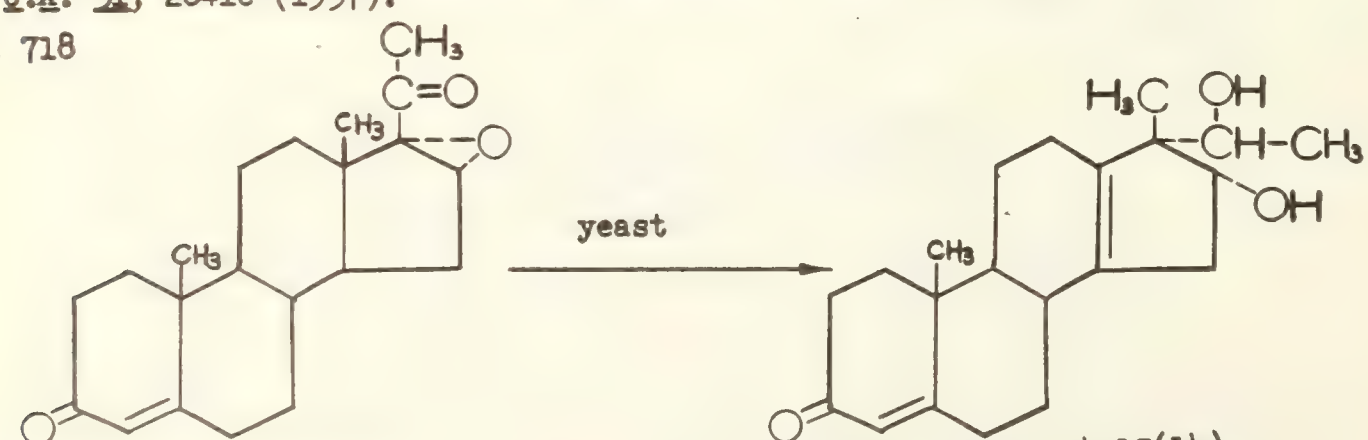
16α-hydroxyprogesterone

Δ^{4}-pregnene-16α,20β-diol-3-one

Camerino and Vercellone, Gazz. chim. ital. 86, 260-5 (1956).

C.A. 51, 2841c (1957).

Rx. 718



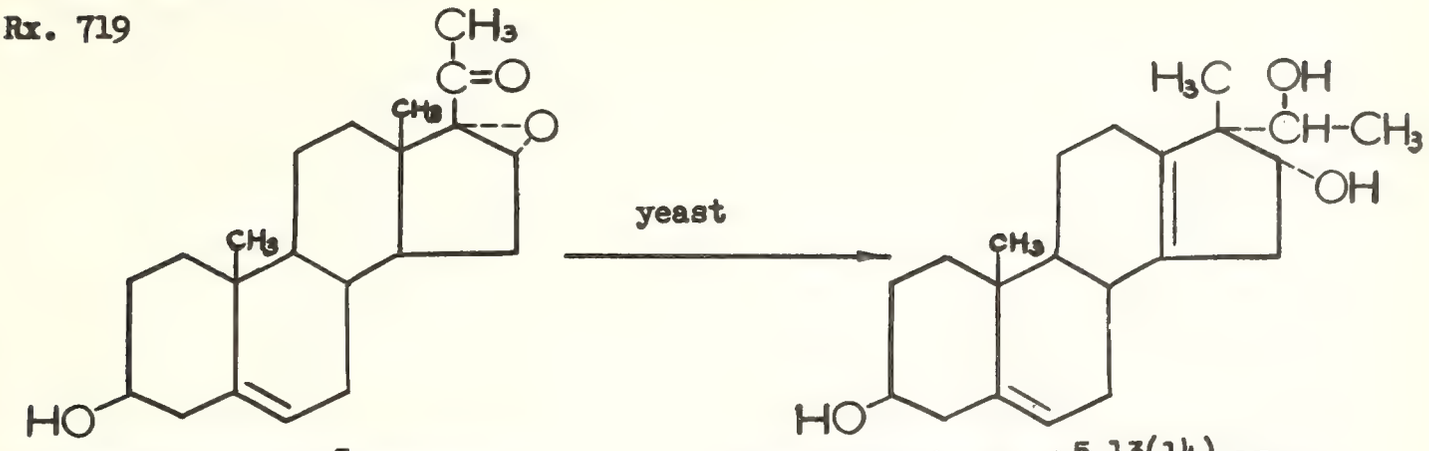
16α,17α-epoxidoprogesterone

17β-methyl-18-nor-$\Delta^{4,13(14)}$-(17)-α-pregnadiene-16α,20-diol-3-one (60%)

Camerino and Vercellone, Gazz. chim. ital. 86, 260-5 (1956).

C.A. 51, 2841c (1957).

Rx. 719



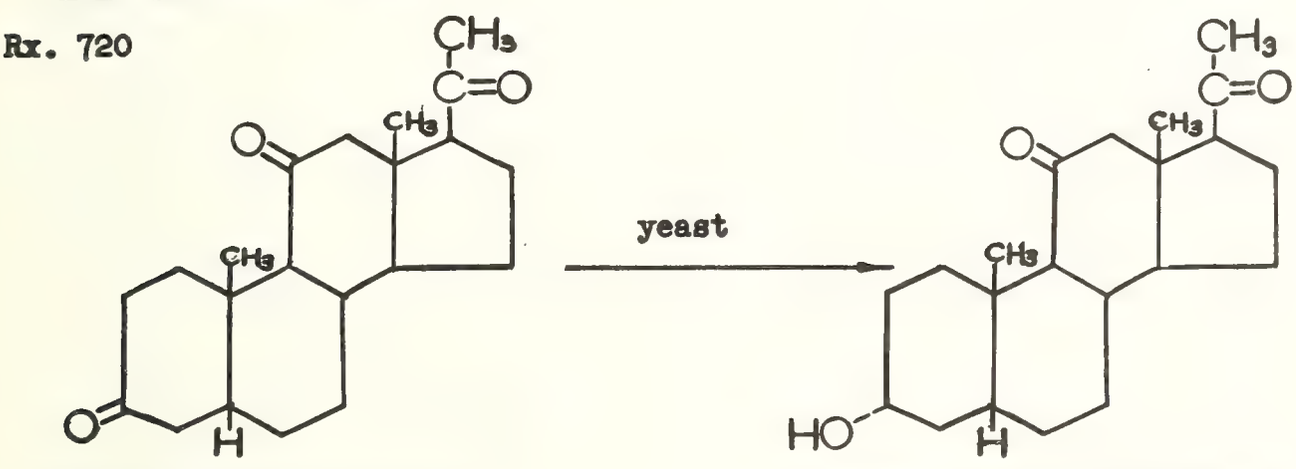
16α,17α-epoxido-Δ^5-pregnene-3β-ol-20-one

17β-methyl-18-nor-$\Delta^{5,13(14)}$-17α-pregnadiene-3β,16α,20-triol (20%)

Camerino et al., Helv. Chim. Acta 36, 1945-8 (1953).

C.A. 48, 4050c (1954).

Rx. 720



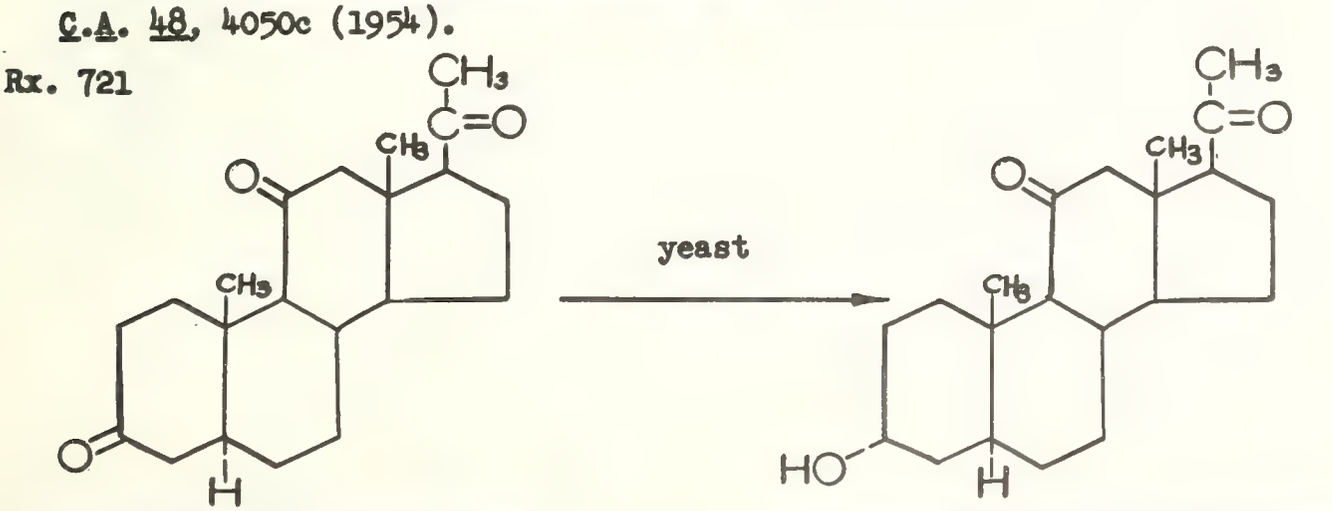
pregnane-3,11,20-trione

pregnane-3α-ol-11,20-dione (approx. 60%)

Camerino et al., Helv. Chim. Acta 36, 1945-8 (1953).

C.A. 48, 4050c (1954).

Rx. 721



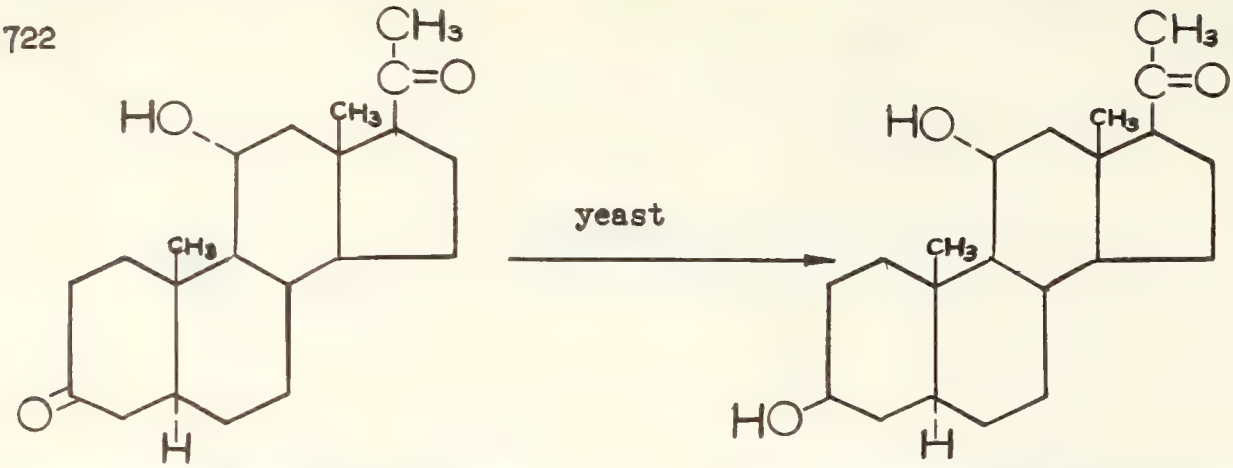
allopregnane-3,11,20-trione

allopregnane-3α-ol-11,20-dione (approx. 44%)

Camerino et al., Helv. Chim. Acta 36, 1945-8 (1953).

C.A. 48, 4050c (1954).

Rx. 722



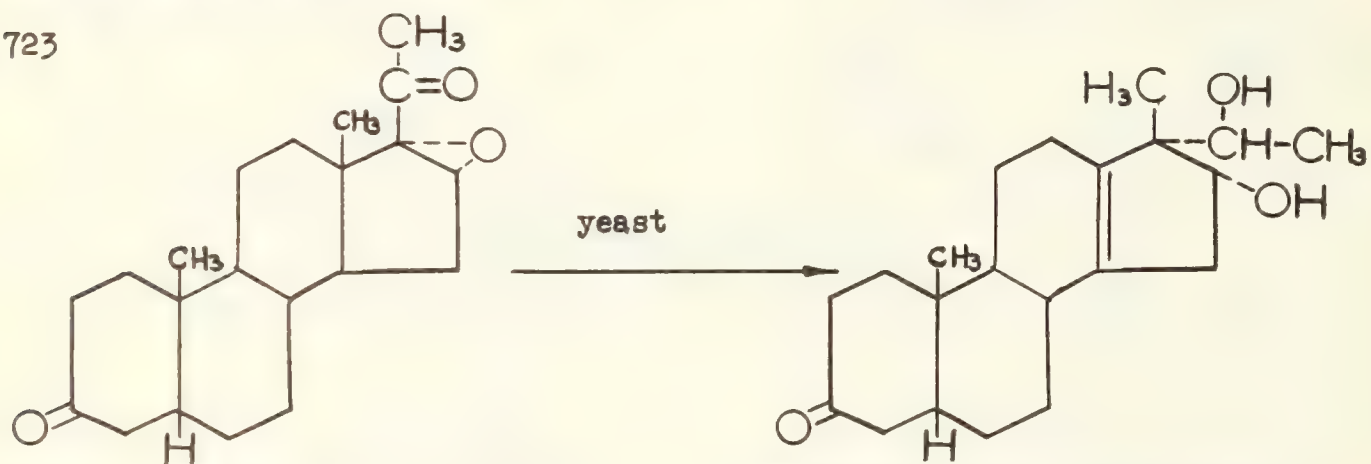
allopregnane-11α-ol-3,20-dione

allopregnane-3β,11α-diol-20-one
(approx. 60%)

Camerino and Vercellone, Gazz. chim. ital. 86, 260-5 (1956).

C.A. 51, 2841c (1957).

Rx. 723



16α,17α-epoxidopregnane-3,20-dione

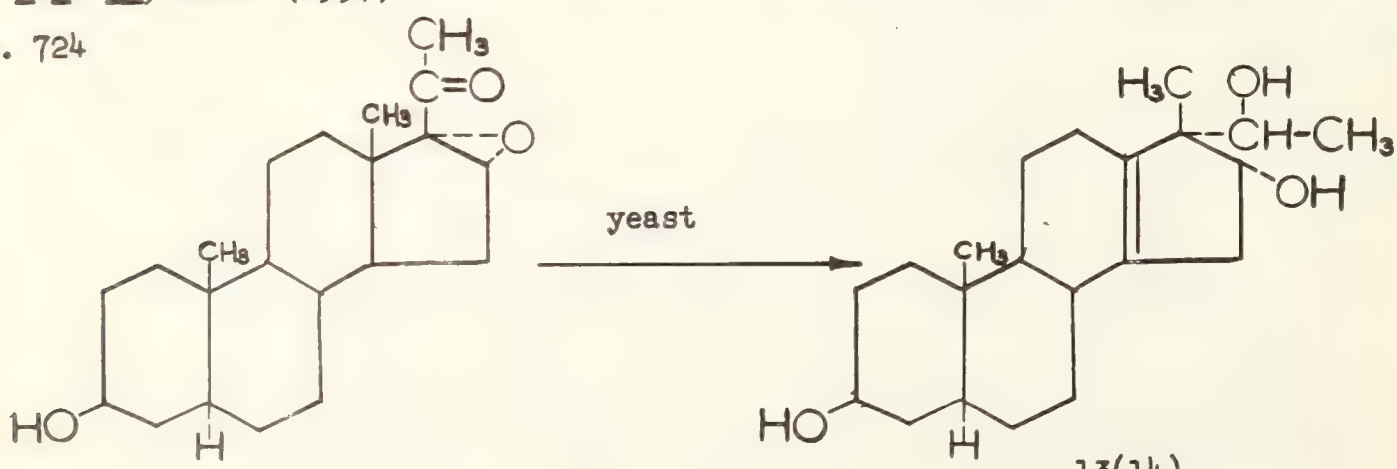
17β-methyl-18-nor-$\Delta^{13(14)}$-17α-pregnene-16α,20-diol-3-one

---

Camerino and Vercellone, Gazz. chim. ital. 86, 260-5 (1956).

C.A. 51, 2841c (1957)

Rx. 724



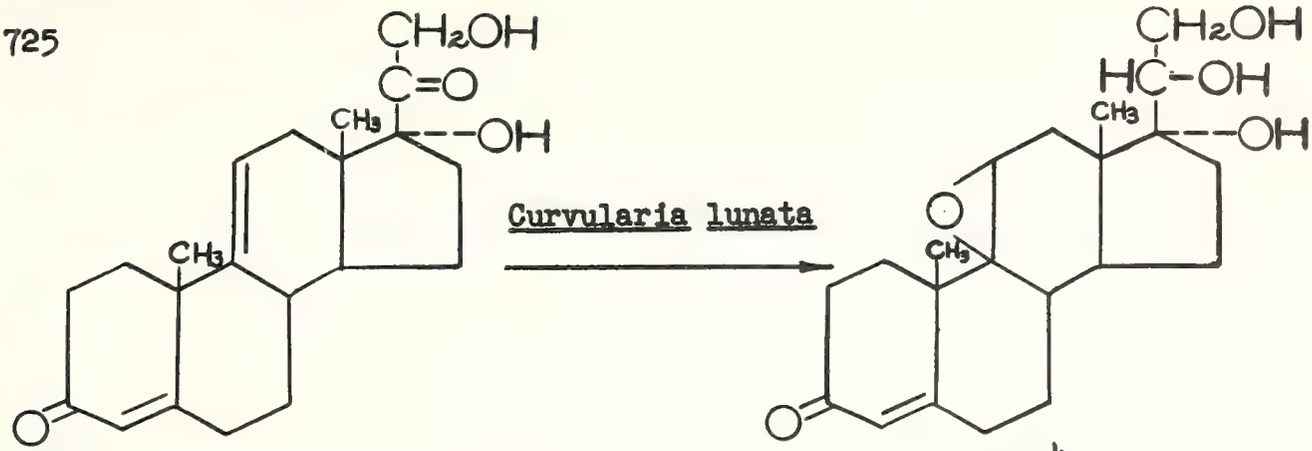
16α,17α-epoxidoallopregnane-3β-ol-20-one

17β-methyl-18-nor-$\Delta^{13(14)}$-17α-allopregnene-3β,16α,20-triol

Bloom et al., in Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 725



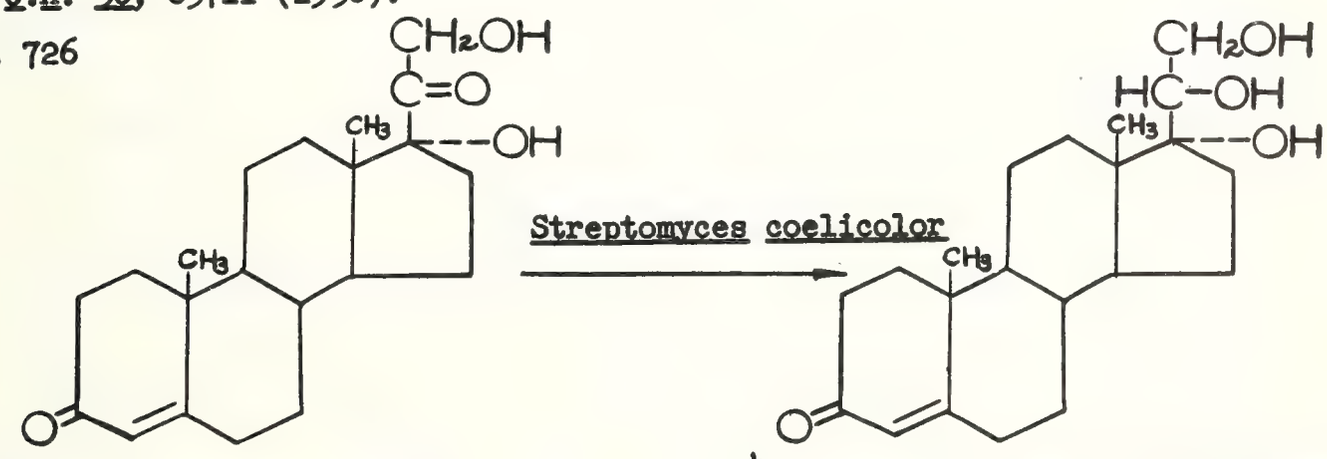
$\Delta^{4,9(11)}$-pregnadiene-17α,21-diol-3,20-dione

9β,11β-epoxido-Δ^{4}-pregnene-17α,20β,21-triol-3-one

Vischer et al., in Wettstein, Experientia 11, 465-79 (1955).

C.A. 50, 6571i (1956).

Rx. 726



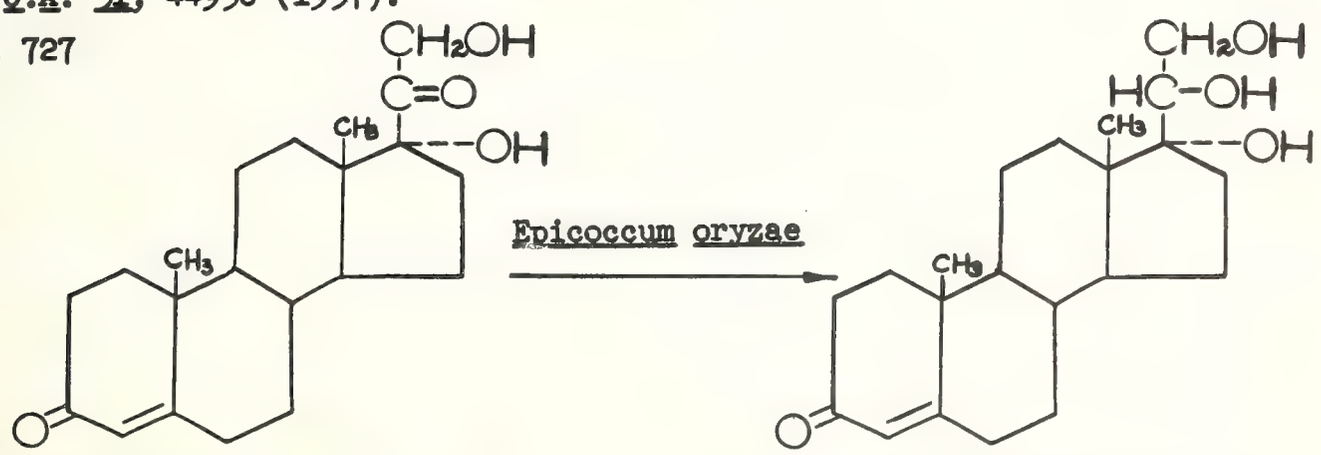
17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd.S)

Δ^{4}-pregnene-17α,20β,21-triol-3-one

Shull, Trans. N.Y. Acad. Sci. 19, 147-72 (1956).

C.A. 51, 4495c (1957).

Rx. 727



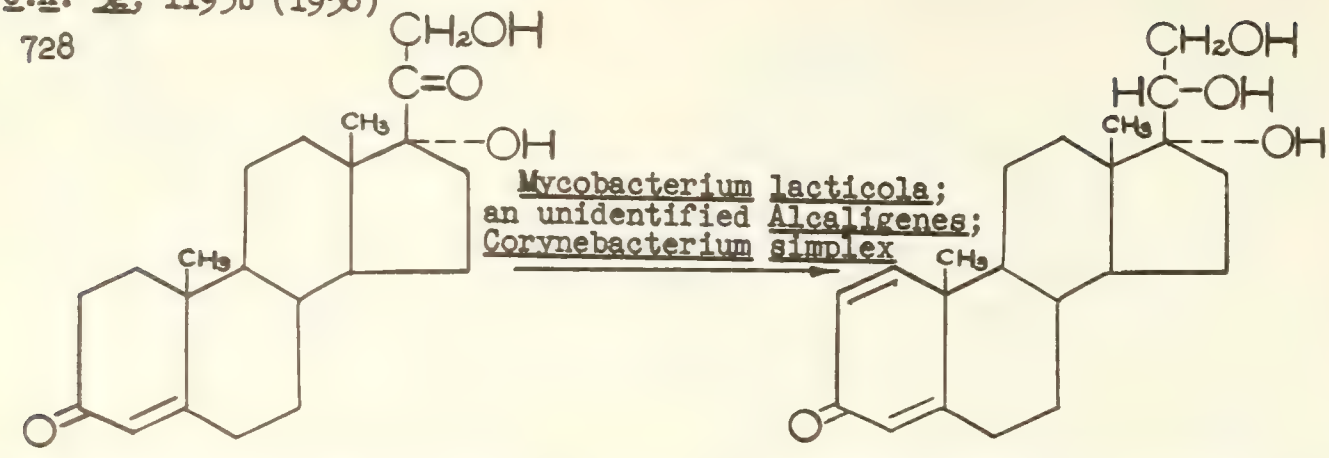
17α-hydroxy-11-desoxycorticosterone

Δ^{4}-pregnene-17α,20β,21-triol-3-one

Sutter et al., J. Org. Chem. 22, 578-9 (1957).

C.A. 52, 1193b (1958)

Rx. 728



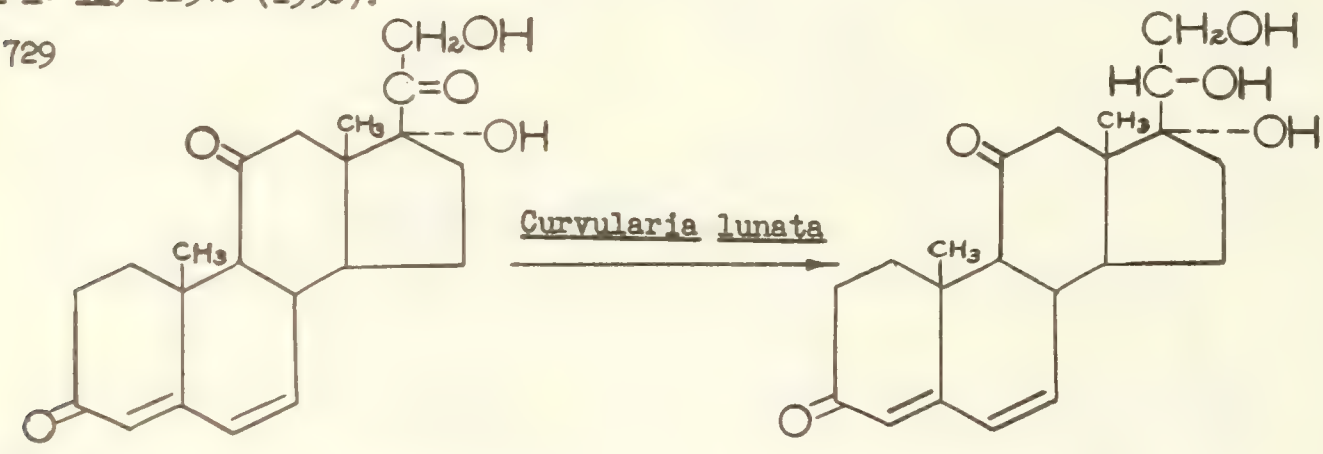
17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd. S)

$\Delta^{1,4}$-pregnadiene-17α,20β,21-triol-3-one

Gould et al., J. Org. Chem. 22, 829-30 (1957).

C.A. 52, 2154e (1958).

Rx. 729



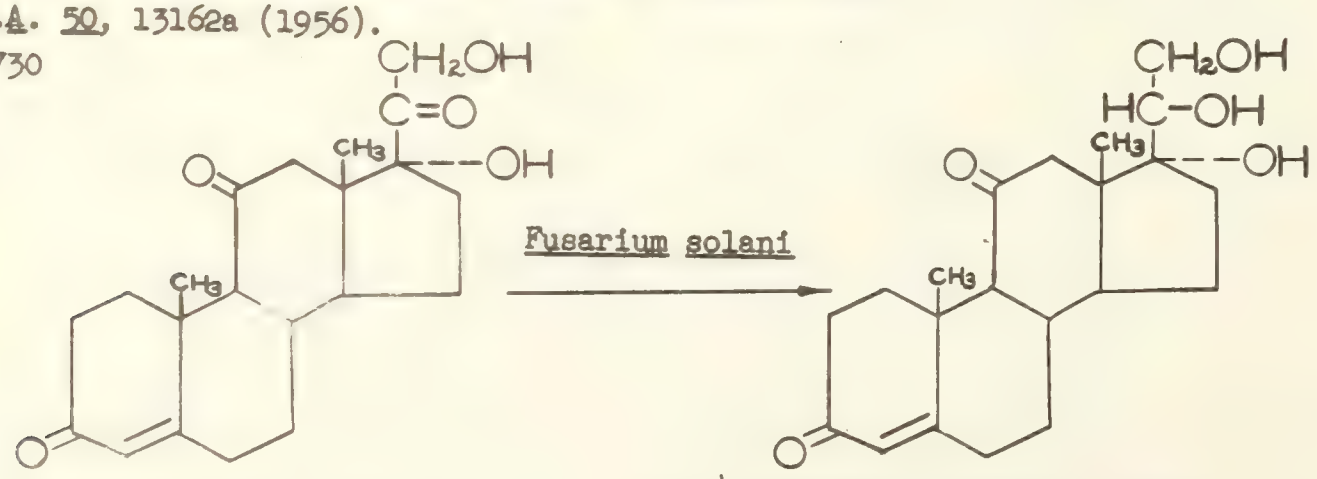
$\Delta^{4,6}$-pregnadiene-17α-21-diol-3,11,20-trione

$\Delta^{4,6}$-pregnadiene-17α,20β,21-triol-3,11-dione (20-25%)

Szpilfogel et al., Rec. trav. chim. 75, 402-4 (1956).

C.A. 50, 13162a (1956).

Rx. 730



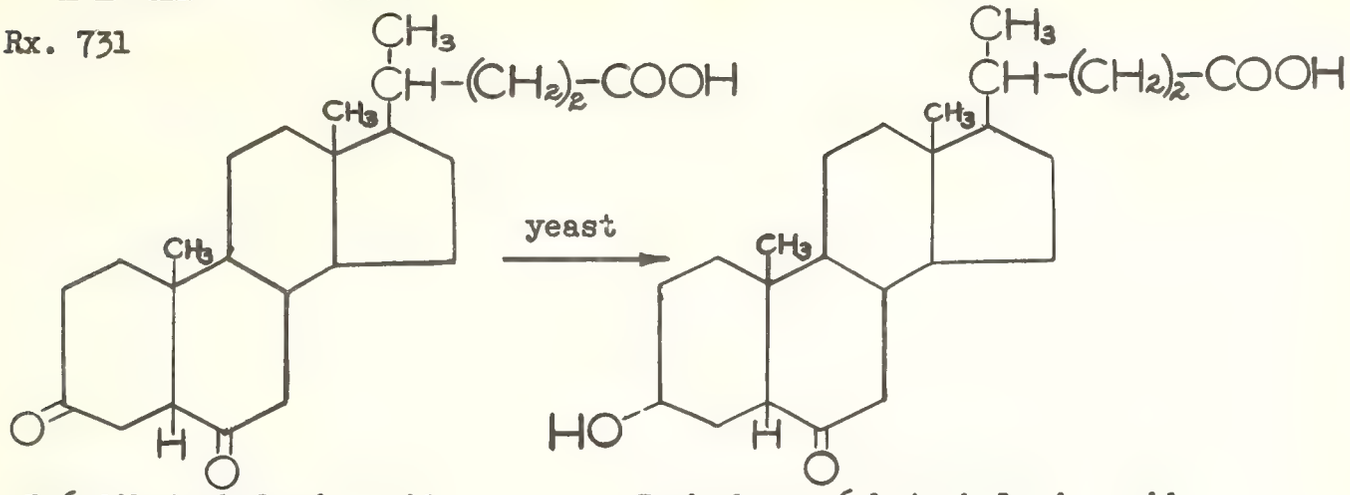
cortisone

Δ^{4}-pregnene-17α,20β,21-triol-3,11-dione

Ercoli and deRuggieri, Boll. soc. ital. biol. sper. 28, 611-12 (1952).

C.A. 49, 426c (1955).

Rx. 731



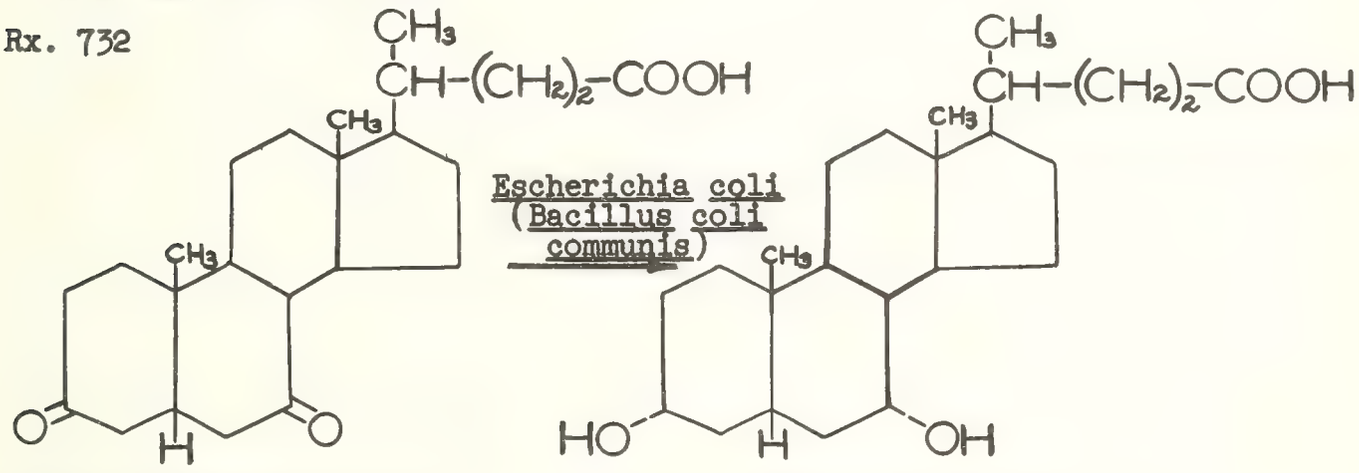
3,6-diketocholanic acid

3α-hydroxy-6-ketocholanic acid

Sihn, J. Biochem. (Japan) 28, 165-8 (1938).

C.A. 32, 9153[2] (1938).

Rx. 732



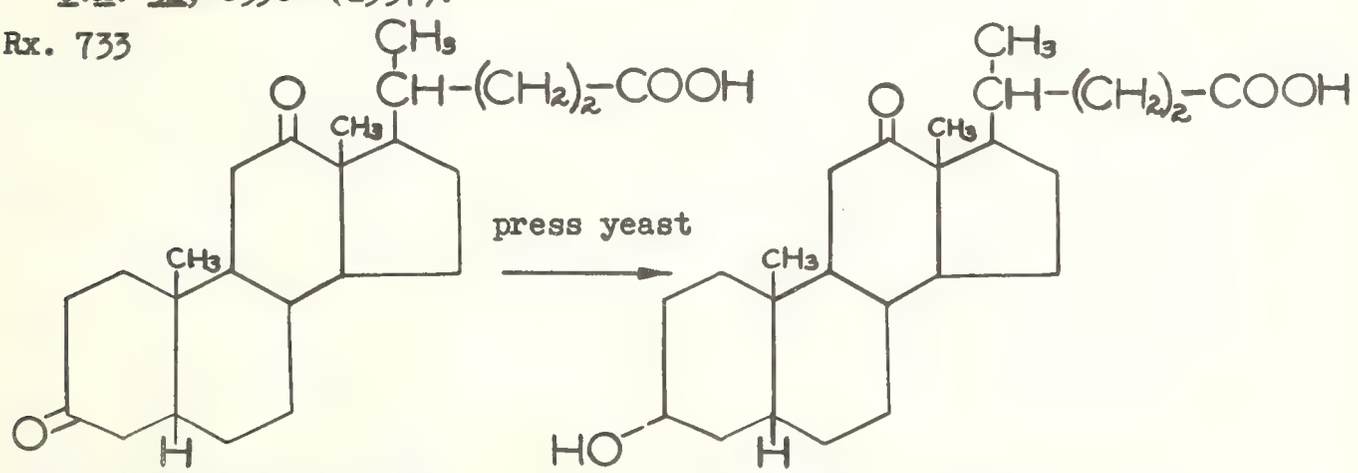
3,7-diketocholanic acid

3α,7α-dihydroxycholanic acid
(chenodesoxycholic acid)

Kim, Enzymologia 4, 119-21 (1937).

C.A. 31, 8598[2] (1937).

Rx. 733



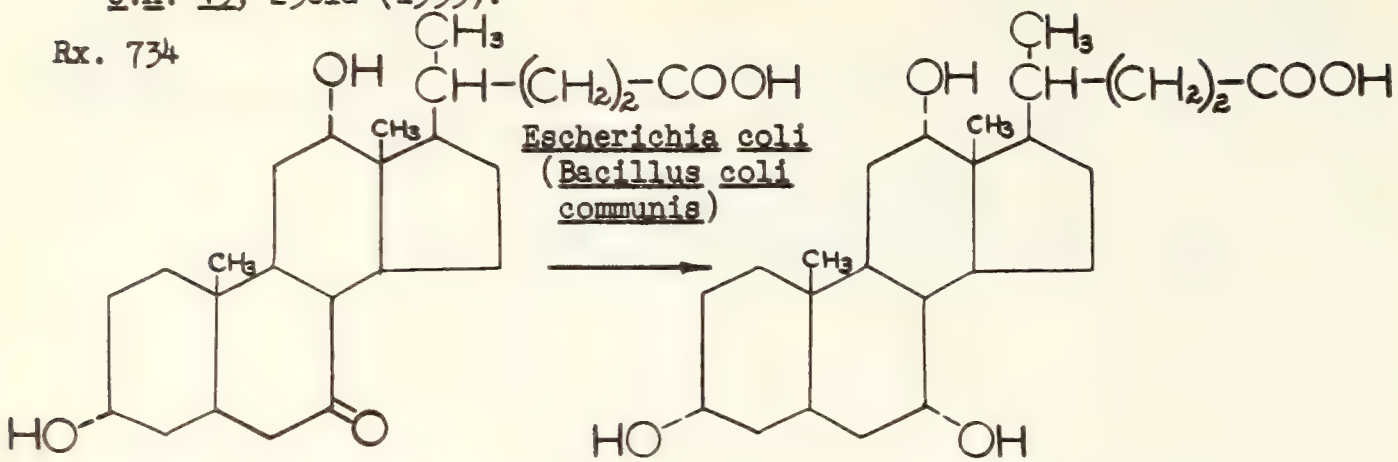
3,12-diketocholanic acid
(dehydrodesoxycholic acid)

3α-hydroxy-12-ketocholanic acid
(approx. 11%)

Machida, Hiroshima J. Med. Sci. 2, 291-4 (1953).

C.A. 49, 2561a (1955).

Rx. 734



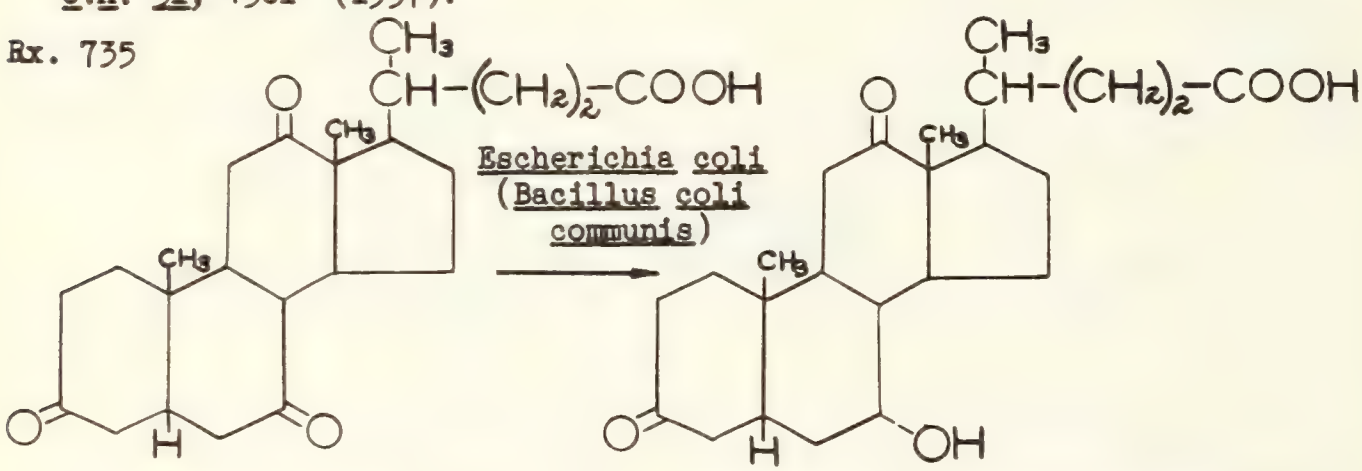
3α,12α-dihydroxy-7-keto-cholanic acid

cholic acid

Fukui, J. Biochem. (Japan) 25, 61-9 (1937).

C.A. 31, 4361[7] (1937).

Rx. 735



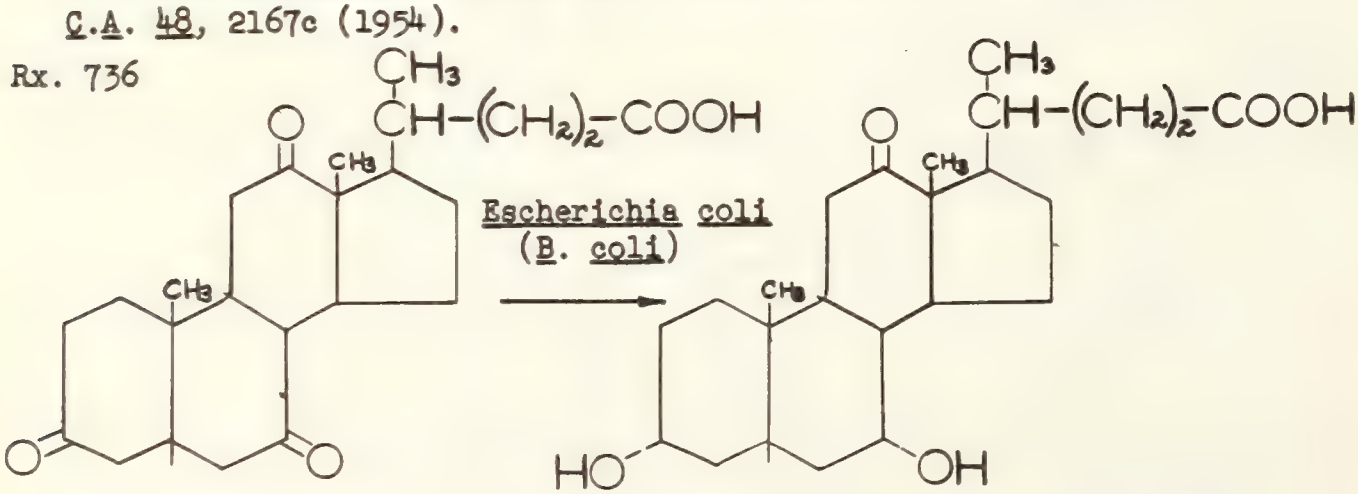
3,7,12-triketocholanic acid (dehydrocholic acid)

7α-hydroxy-3,12-diketocholanic acid

Machida, J. Biochem. (Japan) 40, 435-7 (1953).

C.A. 48, 2167c (1954).

Rx. 736



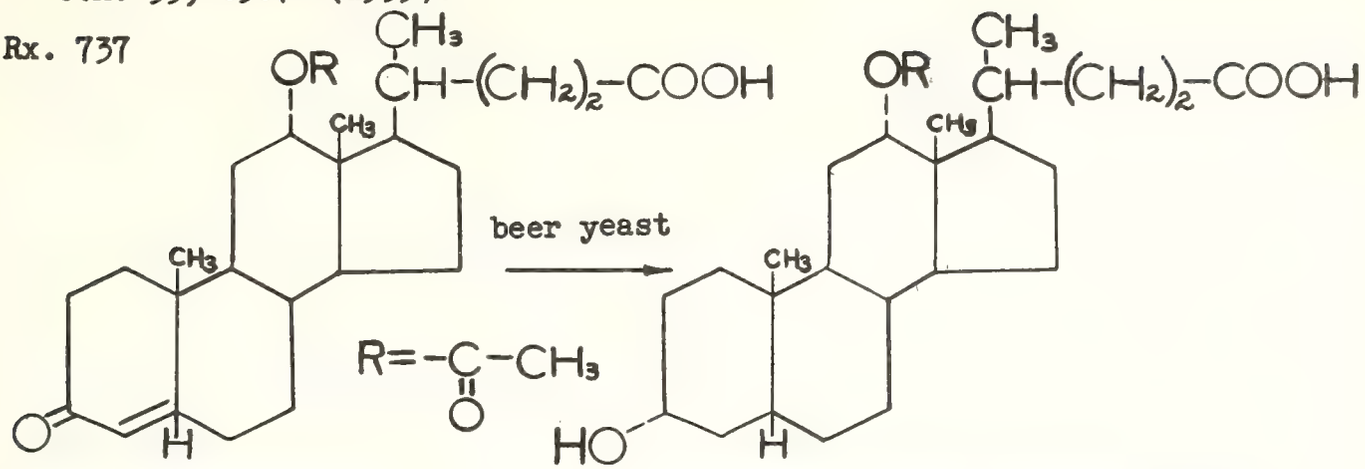
3,7,12-triketocholanic acid

3α,7α-dihydroxy-12-ketocholanic acid

Kim, Enzymologia 6, 105-7 (1939).

C.A. 33, 6367[1] (1939).

Rx. 737



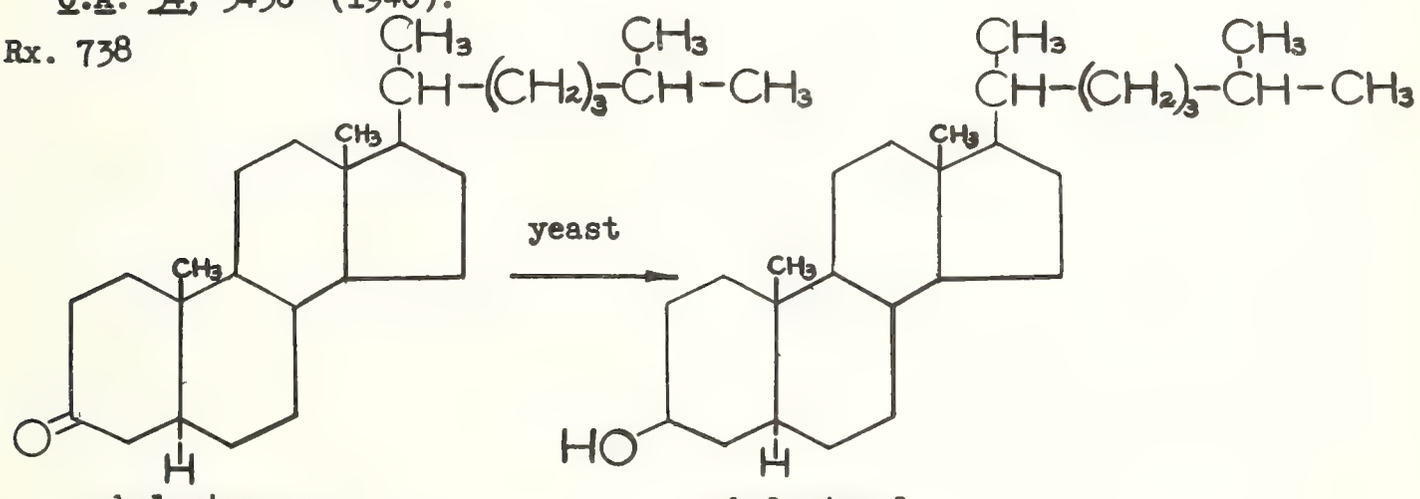
3-keto-12-acetoxycholanic acid

3α-hydroxy-12-acetoxycholanic acid (33%)

Mamoli, U.S. 2,186,906 (Jan. 9, 1940).

C.A. 34, 3436[8] (1940).

Rx. 738



cholestanone

cholestanol

II. Reduction

b. $-CHO \longrightarrow -CH_2OH$

Langlykke and Fred, J. Bacteriol. 33, 102 (1937).

C.A. 31, 3095[1] (1937).

Rx. 739

$$CH_3-CHO \xrightarrow{\text{Clostridium butylicum}} CH_3-CH_2OH$$

acetaldehyde — ethanol

Neuberg and Schwenk, Biochem. Z. 71, 114-17 (1915).

C.A. 9, 3058[6] (1915).

Rx. 740

$$\begin{matrix} CH_2-CHO \\ | \\ OH \end{matrix} \xrightarrow{\text{yeast}} \begin{matrix} CH_2-CH_2 \\ | \quad | \\ OH \quad OH \end{matrix}$$

glycolaldehyde — 1,2-ethanediol (ethylene glycol)

Lintner and Lüers, Z. physiol. Chem. 88, 122-3 (1913).

C.A. 8, 1126[9] (1914).

Rx. 741

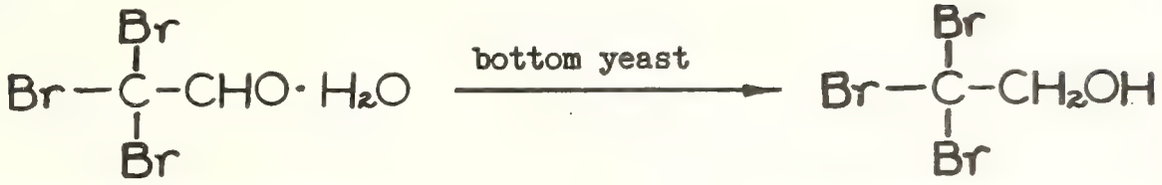
$$\begin{matrix} Cl \\ | \\ Cl-C-CHO \cdot H_2O \\ | \\ Cl \end{matrix} \xrightarrow{\text{yeast}} \begin{matrix} Cl \\ | \\ Cl-C-CH_2OH \\ | \\ Cl \end{matrix}$$

trichloroacetaldehyde hydrate (chloral hydrate) — 2,2,2-trichloroethanol (40%) For 70% yield, see Willstätter and Duisberg, Ber. 56B, 2283 (1923).

Willstätter and Duisberg, Ber. 56B, 2283-6 (1923).

C.A. 18, 1110[1] (1924).

Rx. 742



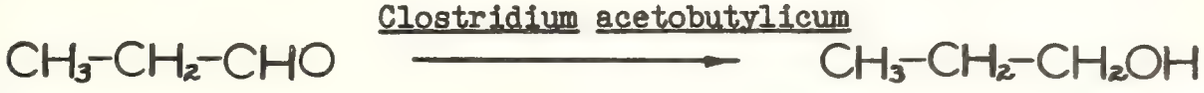
tribromoacetaldehyde hydrate (bromal hydrate)

2,2,2-tribromoethanol (29.5%)

Blanchard and MacDonald, J. Biol. Chem. 110, 145-50 (1935).

C.A. 29, 4793[4] (1935).

Rx. 743



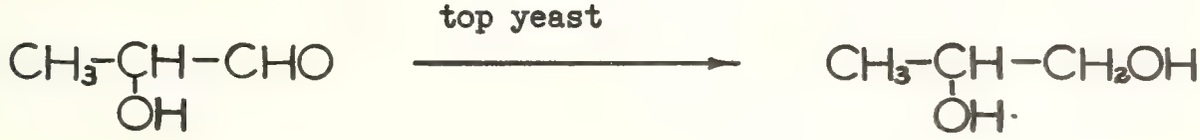
propionaldehyde

1-propanol (72%)

Neuberg and Vercellone, Biochem. Z. 279, 140-2 (1935).

C.A. 29, 8057[2] (1935).

Rx. 744



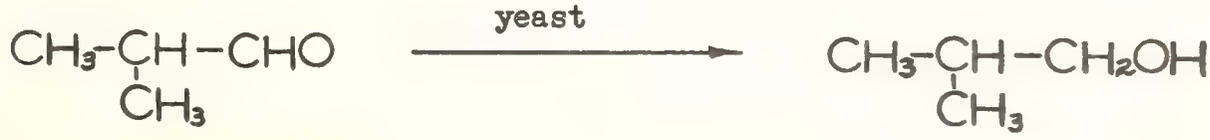
D,L-lactaldehyde

1,2-propanediol (65%) (predominantly D-isomer)

Neuberg and Kerb, Biochem. Z. 53, 406-19 (1913).

Brit. C.A. 104 [ii], 1026 (1913).

Rx. 745



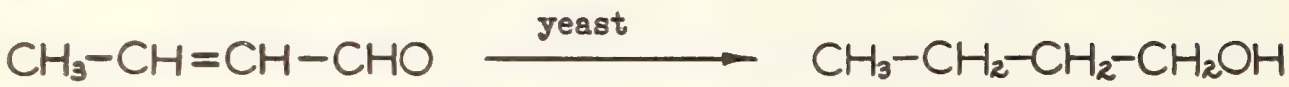
2-methylpropionaldehyde (isobutyraldehyde)

2-methyl-1-propanol (isobutyl alcohol)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 746

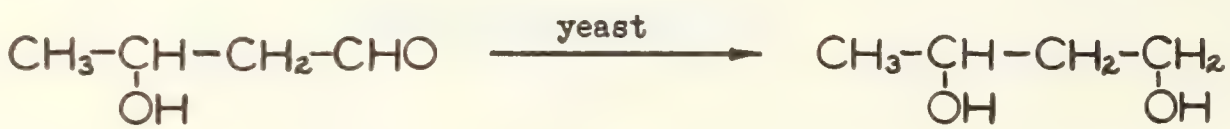


crotonic aldehyde — 1-butanol (8.3%)

Neuberg and Kerb, Biochem. Z. 92, 96-110 (1918).

C.A. 13, 2046[2] (1919).

Rx. 747

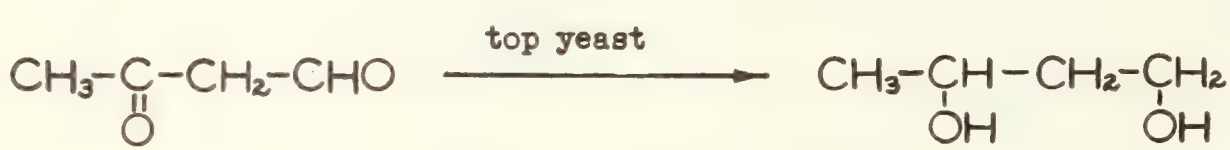


β-hydroxybutyraldehyde — d-1,3-butanediol (63.5%)

Grzycki, Biochem. Z. 265, 195-8 (1933).

C.A. 28, 189[6] (1934).

Rx. 748

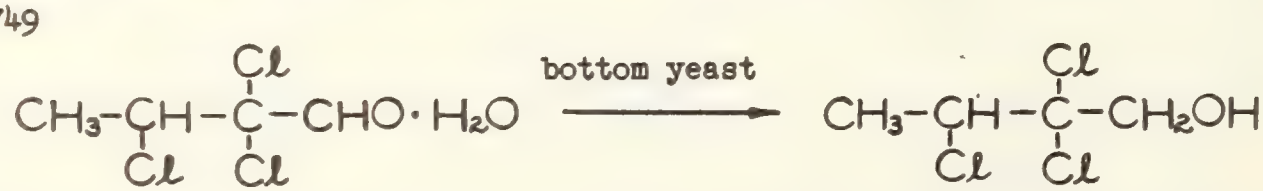


β-ketobutyraldehyde — d-1,3-butanediol

Rosenfeld, Biochem. Z. 156, 54-7 (1925).

C.A. 19, 2683[2] (1925).

Rx. 749



2,2,3-trichlorobutyraldehyde — 2,2,3-trichloro-1-butanol (74%)

Neuberg and Steenbock, Biochem. Z. 52, 494-503 (1913).

C.A. 8, 359[3] (1914).

Rx. 750

n-valeraldehyde → 1-pentanol (66-84%) (amyl alcohol)

Neuberg and Kerb, Ber. 46B, 2225-8 (1913). See Biochem. Z. 53, 406 (1913).

C.A. 7, 3514[2] (1913).

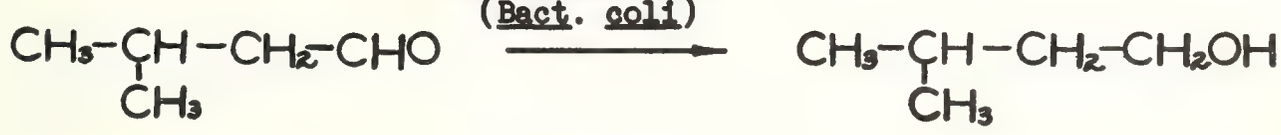
Rx. 751

β-methylbutyraldehyde (isovaleraldehyde) → 3-methyl-1-butanol (67%)

Neuberg and Simon, Biochem. Z. 190, 226-31 (1927).

C.A. 22, 1991[1] (1928).

Rx. 752

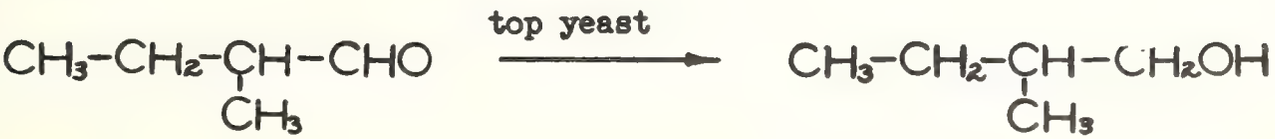


β-methylbutyraldehyde → 3-methyl-1-butanol (73%)

Neuberg and Ringer, Biochem. Z. 90, 388-94 (1918).

C.A. 13, 2045[9] (1919).

Rx. 753

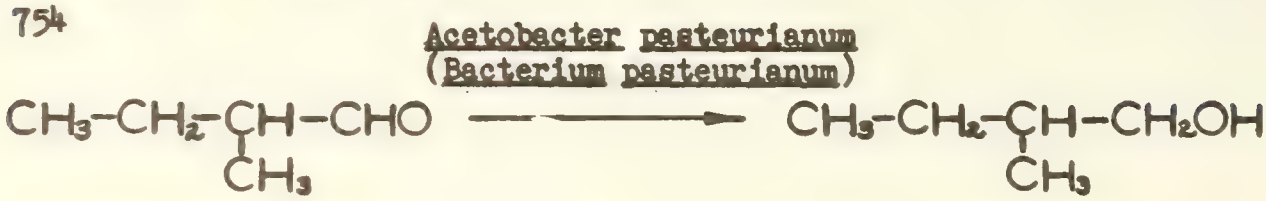


α-methylbutyraldehyde → 2-methyl-1-butanol (70%)

Neuberg and Simon, Biochem. Z. 179, 443-50 (1926).

C.A. 21, 1998[2] (1927).

Rx. 754

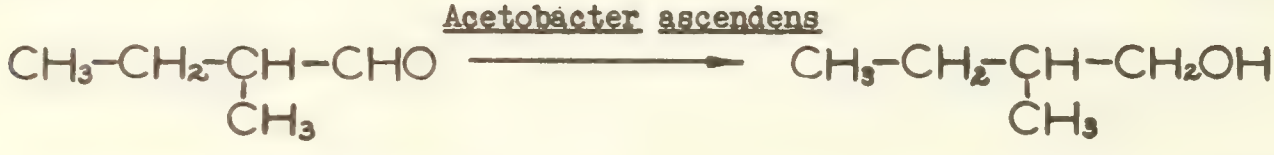


d,l-α-methylbutyraldehyde — d-2-methyl-1-butanol (approx. 18%)

Neuberg and Simon, Biochem. Z. 179, 443-50 (1926).

C.A. 21, 1998[2] (1927).

Rx. 755

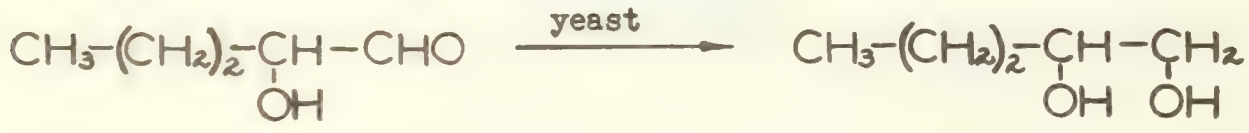


d,l-α-methylbutyraldehyde — l-2-methyl-1-butanol

Levene and Walti, J. Biol. Chem. 94, 361-6 (1931).

C.A. 26, 1901[2] (1932).

Rx. 756

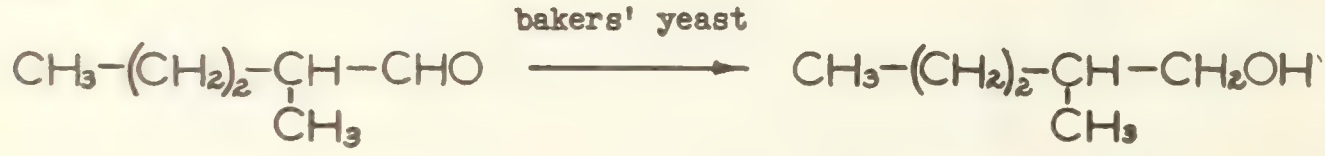


α-hydroxyvaleraldehyde — d-1,2-pentanediol

Neuberg, Biochim. et Biophys. Acta 4, 170-8 (1950).

C.A. 44, 3669g (1950).

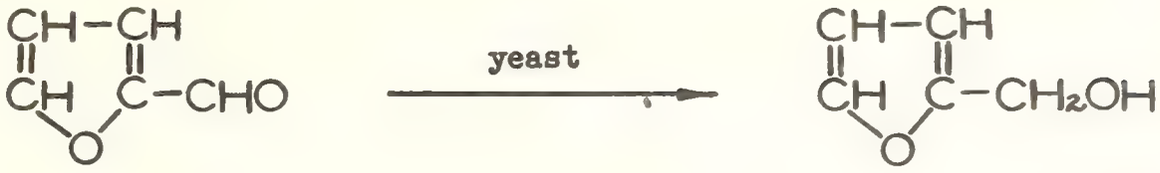
Rx. 757



α-methylvaleraldehyde — 2-methyl-1-pentanol (63%)

Lintner and Liebig, Z. physiol. Chem. 72, 449-54 (1911).
C.A. 5, 3297[6] (1911).

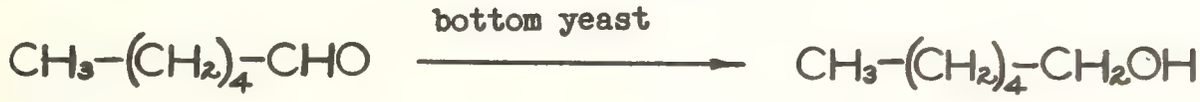
Rx. 758



furfural — furfuryl alcohol

Neuberg and Nord, Biochem. Z. 67, 24-7 (1914).
C.A. 9, 58[6] (1915).

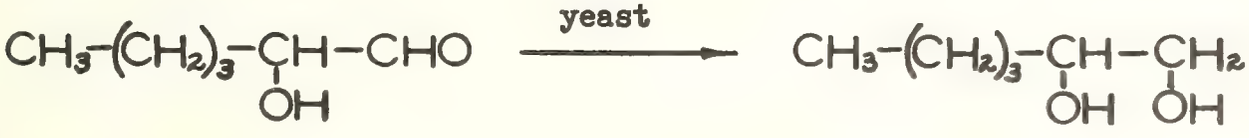
Rx. 759



n-caproaldehyde — 1-hexanol

Levene and Walti, J. Biol. Chem. 94, 361-6 (1931).
C.A. 26, 1901[2] (1932).

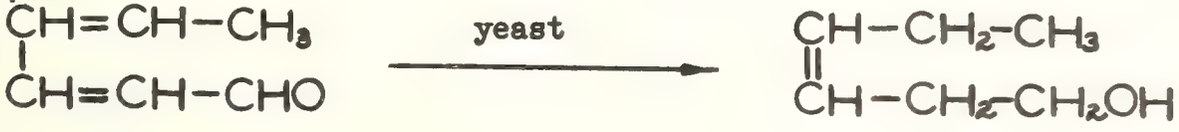
Rx. 760



α-hydroxycaproaldehyde — d-1,2-hexanediol

Fischer and Wiedemann, Ann. 513, 260-80 (1934).
C.A. 29, 1383[9] (1935).

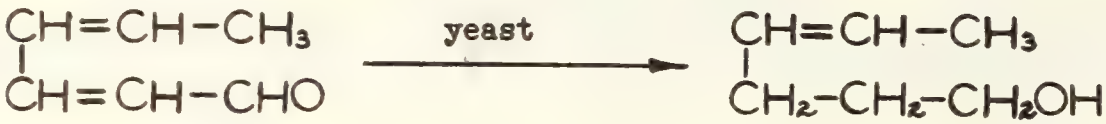
Rx. 761



2,4-hexadienal (sorbic aldehyde) — 3-hexene-1-ol

Fischer and Wiedemann, Ann. 513, 260-80 (1934). See ibid. 522, 1-16 (1936).
C.A. 29, 1383[9] (1935).

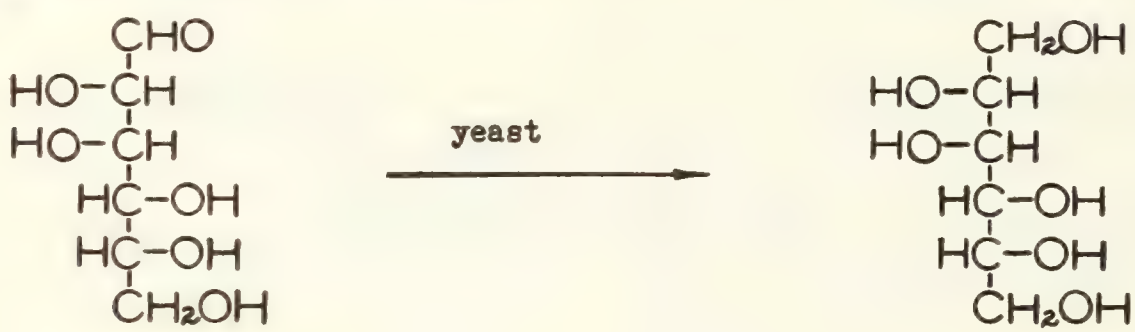
Rx. 762



2,4-hexadienal (sorbic aldehyde) — 4-hexene-1-ol

Fenaroli, Giorn. chim. ind. applicata 4, 85-9 (1922).
C.A. 16, 2570[2] (1922).

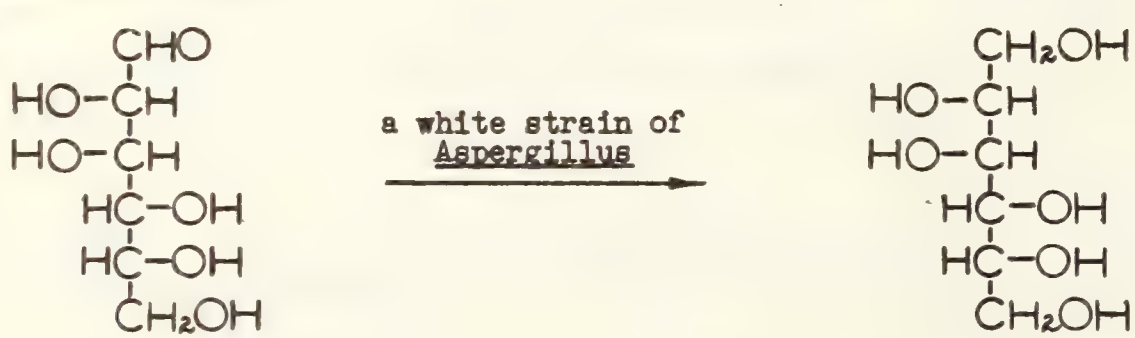
Rx. 763



mannose (manna molasses) — mannitol

Coyne and Raistrick, Biochem. J. 25, 1513-21 (1931).
C.A. 26, 1637[5] (1932).

Rx. 764

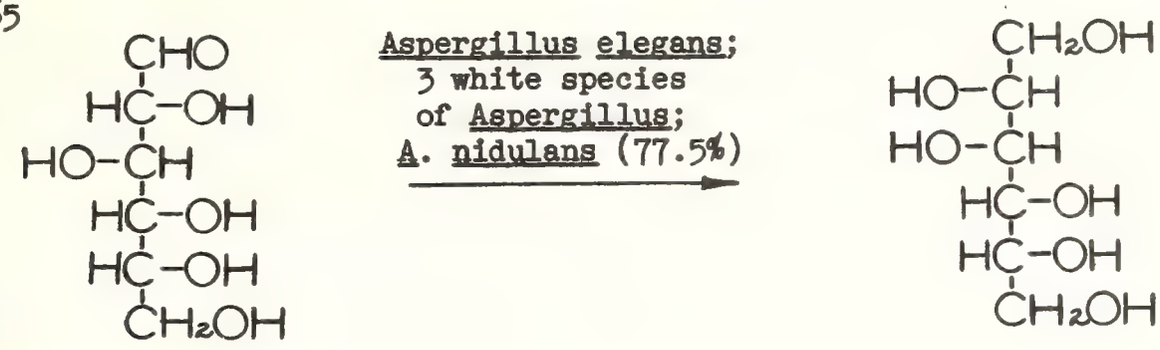


mannose — mannitol (37%)

Birkinshaw et al., Trans. Roy. Soc. (London) B220, 153-71 (1931).

C.A. 26, 2485[6] (1932).

Rx. 765

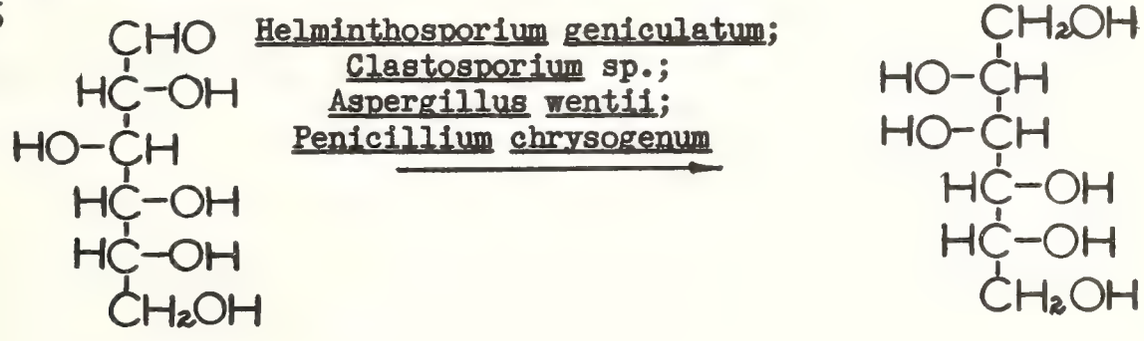


glucose — mannitol

Birkinshaw and Raistrick, Trans. Roy. Soc. (London) B220, 331-53 (1931).

C.A. 26, 2487[2] (1932).

Rx. 766

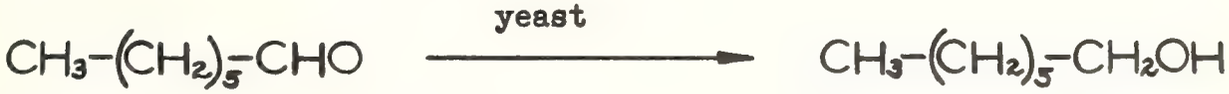


glucose — mannitol

Ohta, Biochem. Z. 59, 183-7 (1914).

C.A. 8, 1805[9] (1914).

Rx. 767

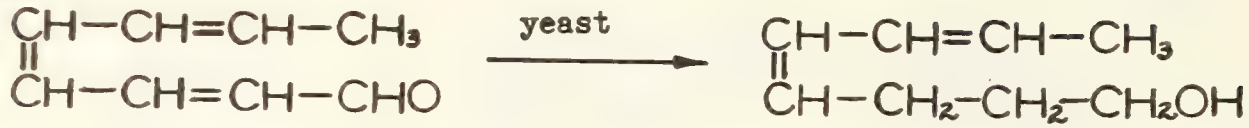


n-heptaldehyde (enanthaldehyde) — 1-heptanol (51%)

Fischer and Wiedemann, Ann. 522, 1-16 (1936).

C.A. 30, 3780[6] (1936).

Rx. 768

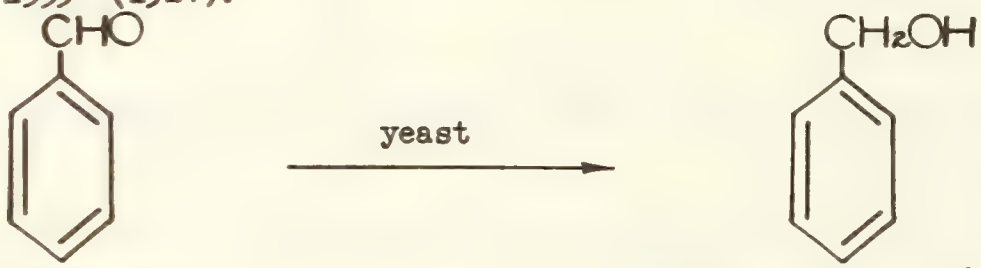


2,4,6-octatrienal — 4,6-octadiene-1-ol

Neuberg and Welde, Biochem. Z. 62, 477-81 (1914).

C.A. 8, 2359[8] (1914).

Rx. 769

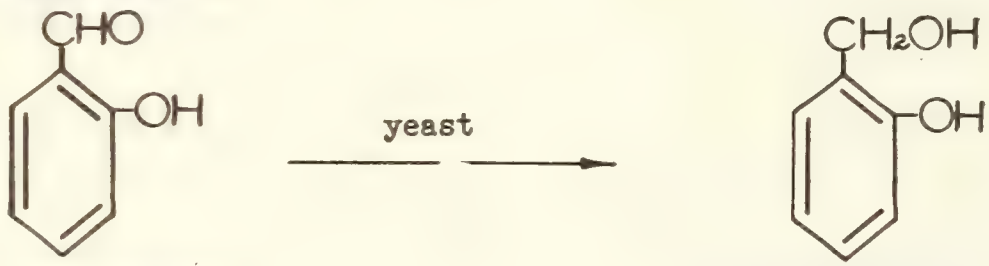


benzaldehyde — benzyl alcohol (22-32%)

Mayer, Biochem. Z. 62, 459-61 (1914).

C.A. 8, 2359[6] (1914).

Rx. 770

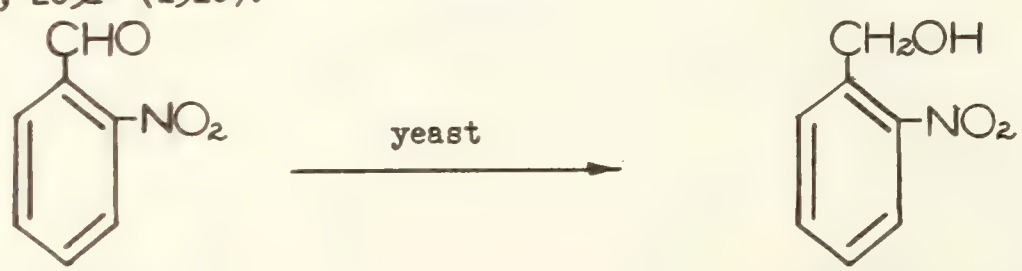


salicylaldehyde — o-hydroxybenzyl alcohol (saligenin)

Nord, Biochem. Z. 103, 315-19 (1920).

C.A. 14, 2652[4] (1920).

Rx. 771

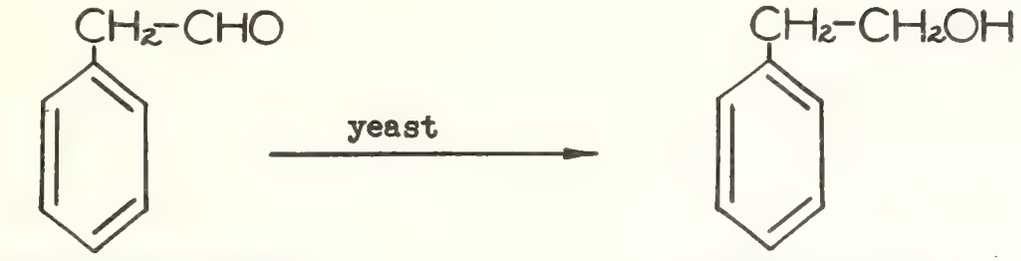


o-nitrobenzaldehyde — o-nitrobenzyl alcohol (10%)

Neuberg and Welde, Biochem. Z. 62, 477-81 (1914).

C.A. 8, 2359[8] (1914).

Rx. 772

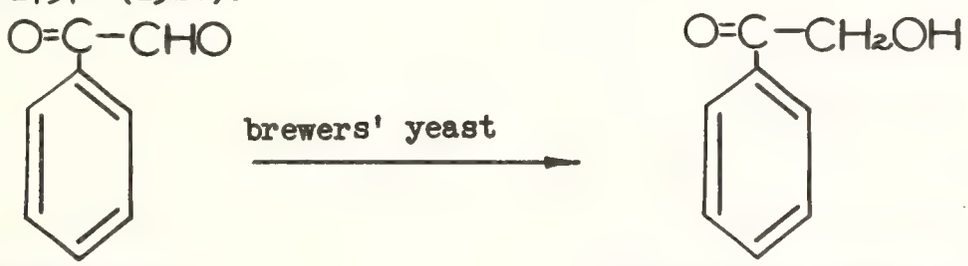


phenylacetaldehyde — β-phenylethanol (61.5-70%)

Dakin, J. Biol. Chem. 18, 91-3 (1914).

C.A. 8, 2737[8] (1914).

Rx. 773

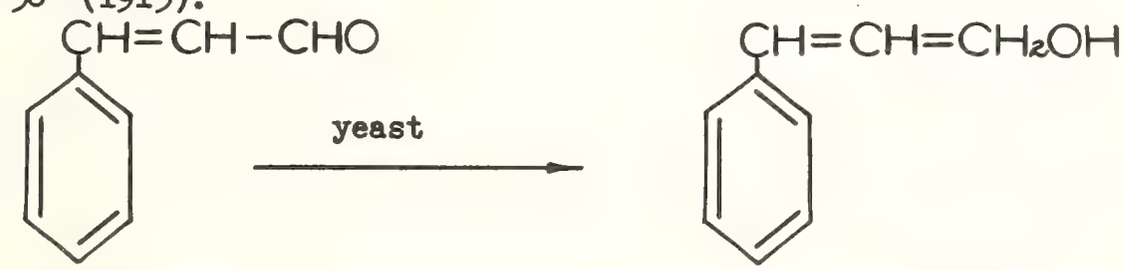


phenylglyoxal — ω-hydroxyacetophenone (approx.19%) (benzoylcarbinol)

Róna, Biochem. Z. 67, 137-42 (1914).

C.A. 9, 58[4] (1915).

Rx. 774

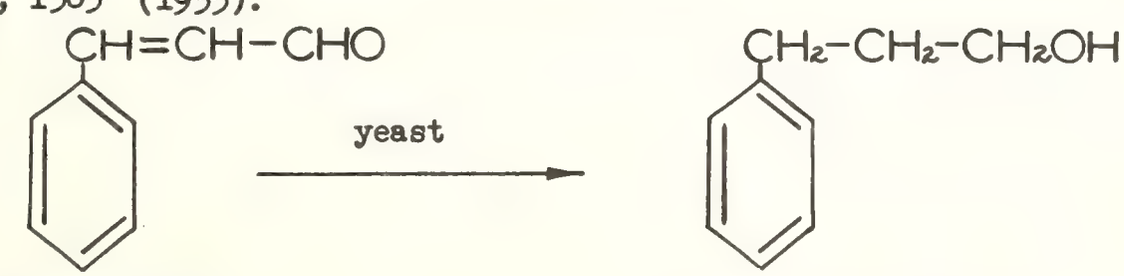


cinnamic aldehyde — cinnamyl alcohol (12%)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 775

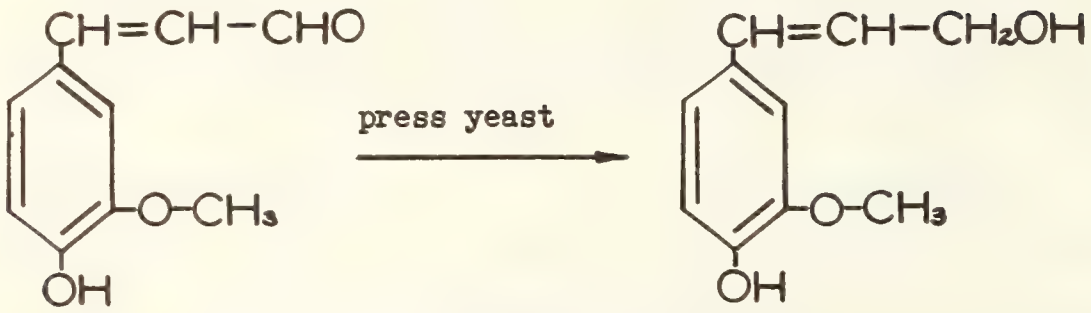


cinnamic aldehyde — 3-phenyl-1-propanol

Pauly and Feuerstein, Ber. 62B, 297-311 (1929).

C.A. 23, 2982[9] (1929).

Rx. 776

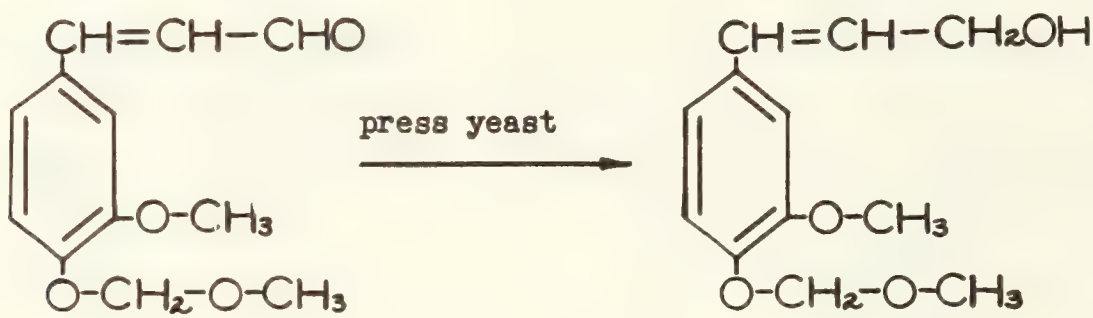


coniferaldehyde — coniferyl alcohol (74%)

Pauly and Feuerstein, Ber. 62B, 297-311 (1929).

C.A. 23, 2982[9] (1929).

Rx. 777



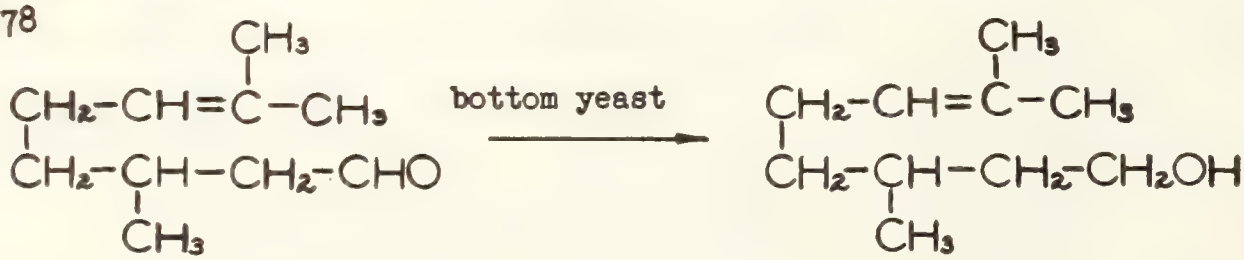
p-O-methoxymethylconiferyl aldehyde — p-O-methoxymethylconiferyl alcohol

---

Mayer and Neuberg, Biochem. Z. 71, 174-9 (1915).

C.A. 9, 3058[6] (1915).

Rx. 778

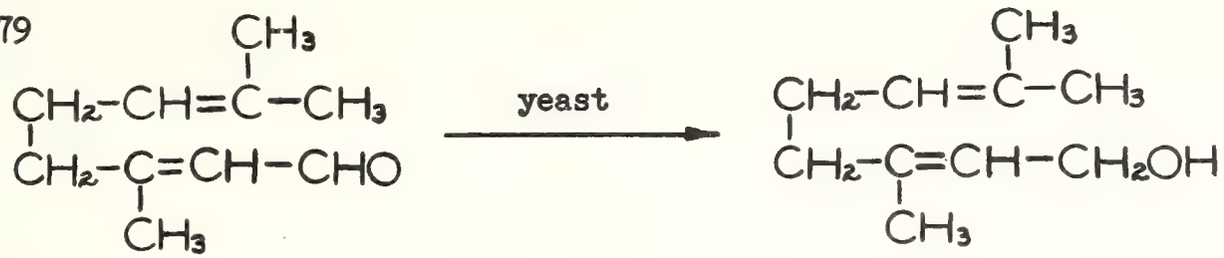


citronellal — citronellol (59%)

Neuberg and Kerb, Biochem. Z. 92, 111-23 (1918).

C.A. 13, 2046[3] (1919).

Rx. 779



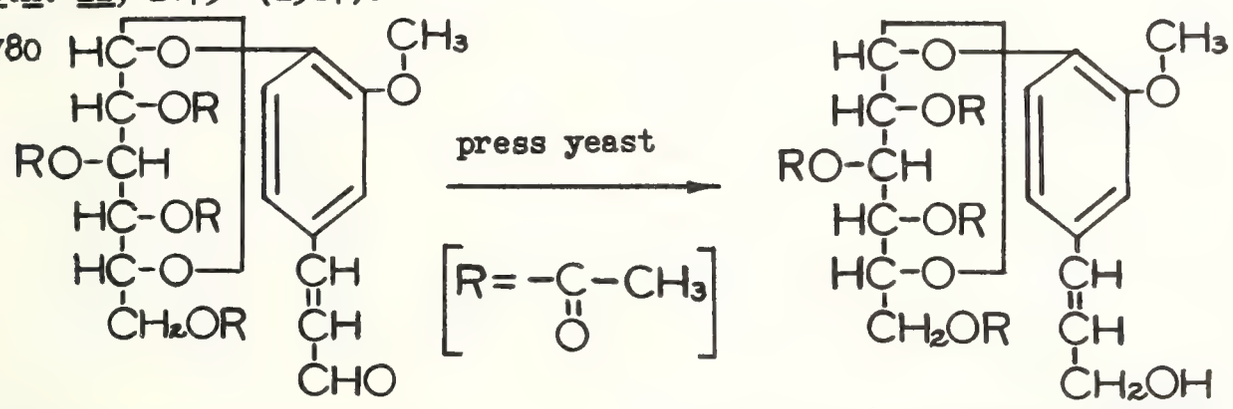
citral

geraniol (approx. 30%)

Pauly and Feuerstein, Ber. 60B, 1031-4 (1927).

C.A. 21, 2475[7] (1927).

Rx.780



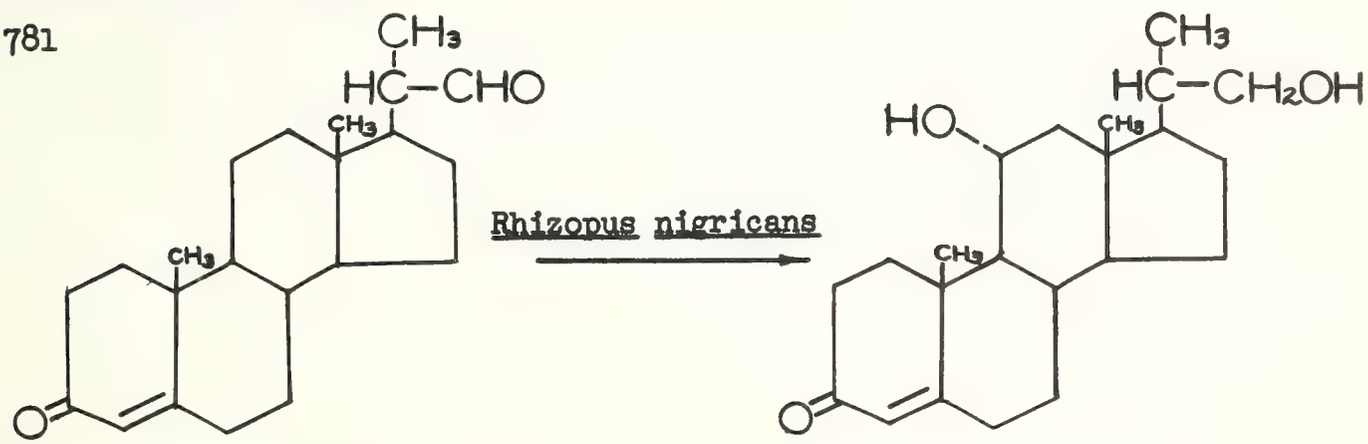
p-O-(2,3,4,6-tetraacetyl-D-gluco-pyranosyl)-coniferaldehyde

p-O-(2,3,4,6-tetraacetyl-D-gluco-pyranosyl)-coniferyl alcohol (83%) (tetraacetylconiferin)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 781



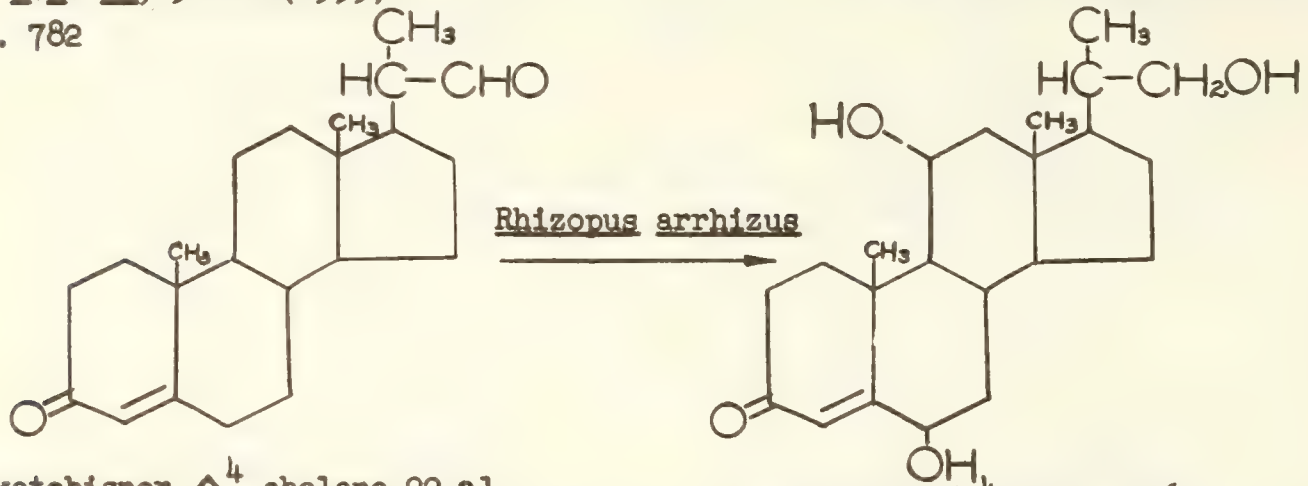
3-ketobisnor-Δ^4-cholene-22-al

3-ketobisnor-Δ^4-cholene-11α, 22-diol (17.4%)

Meister et al., J. Am. Chem. Soc. 76, 5679-82 (1954). See Murray and Peterson, U.S. 2,602,769 (1952).

C.A. 49, 9024b (1955).

Rx. 782



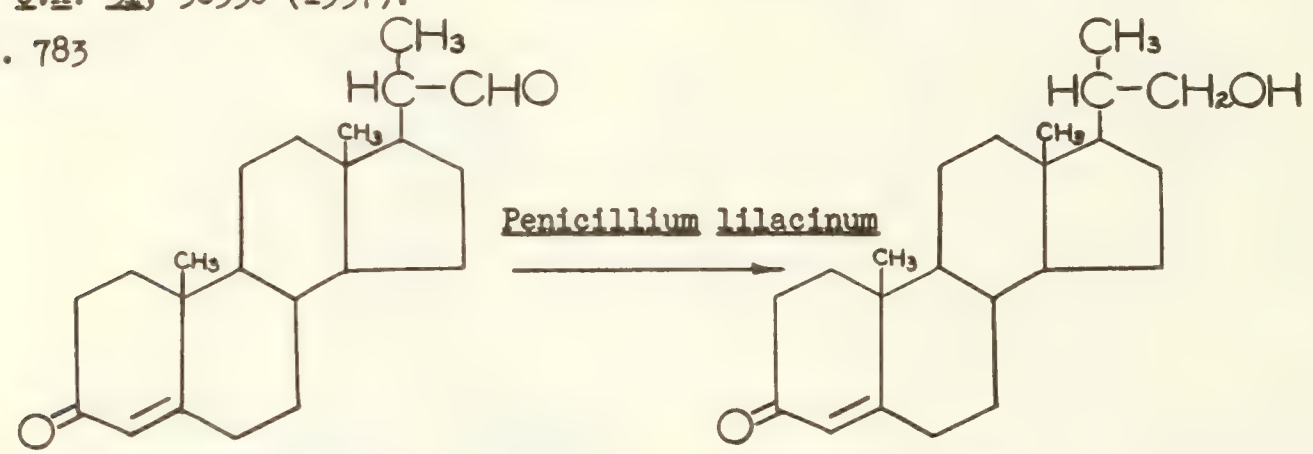
3-ketobisnor-Δ^4-cholene-22-al

3-ketobisnor-Δ^4-cholene-6β,11α, 22-triol (approx. 29%)

Peterson, Record Chem. Progr. 17, 211-40 (1956).

C.A. 51, 3635c (1957).

Rx. 783



3-ketobisnor-Δ^4-cholene-22-al

3-ketobisnor-Δ^4-cholene-22-ol

II. Reduction

c. $-CH=CH- \longrightarrow -CH_2-CH_2-$

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 784

$$CH_3-CH=CH-CHO \xrightarrow{\text{yeast}} CH_3-CH_2-CH_2-CH_2OH$$

crotonic aldehyde (crotonaldehyde) — 1-butanol (8.3%)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 785

$$CH_3-CH=CH-CH_2OH \xrightarrow{\text{yeast}} CH_3-CH_2-CH_2-CH_2OH$$

2-butene-1-ol (crotyl alcohol) — 1-butanol (55-70%)

Fischer and Robertson, Ann. 529, 84-7 (1937).

C.A. 31, 5320[1] (1937).

Rx. 786

$$CH_3-CH=CH-CH_2OH \xrightarrow{\text{Escherichia coli (Bacterium coli)}} CH_3-CH_2-CH_2-CH_2OH$$

2-butene-1-ol — 1-butanol (10-22%)

Peel and Barker, Biochem. J. 62, 323-32 (1956).

C.A. 50, 8790b (1956).

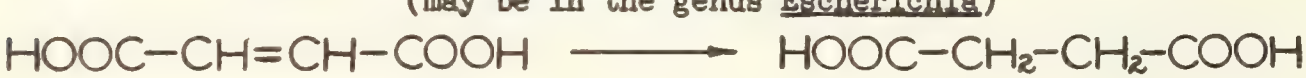
Rx. 787

2,3-butenoic acid — butyric acid

Sakaguchi and Tada, Zentr. Bakt. Parasitenk. II Abt. 101, 341-54 (1940).

C.A. 34, 4105^{2} (1940).

Rx. 788

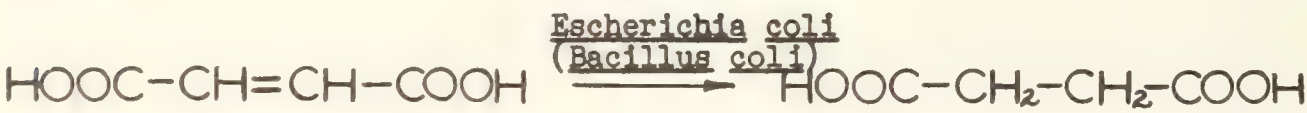


fumaric acid — succinic acid (approx. 28%)

Farkas and Schneidmesser, J. Biol. Chem. 167, 807-9 (1947).

C.A. 41, 3834h (1947).

Rx. 789

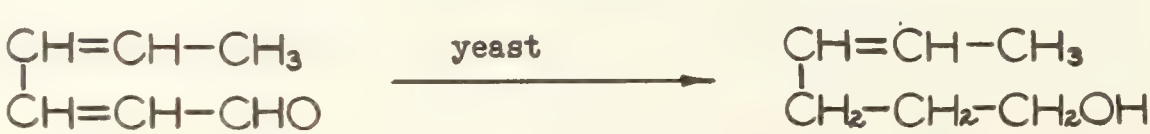


fumaric acid — succinic acid

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383^{9} (1935).

Rx. 790

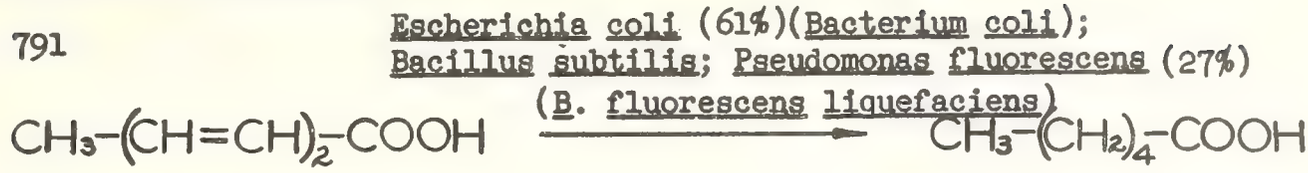


2,3-hexadienal — 4-hexene-1-ol

Schönbrunner, Biochem. Z. 304, 26-36 (1940).

C.A. 34, 4102^{9} (1940).

Rx. 791

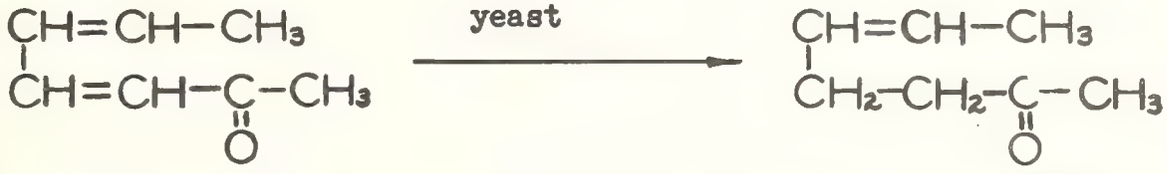


sorbic acid — caproic acid

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959^{8} (1935).

Rx. 792

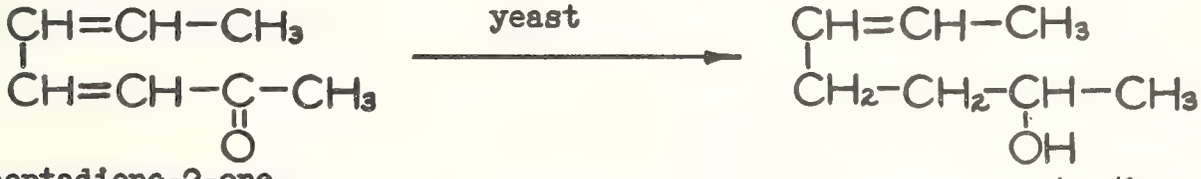


3,5-heptadiene-2-one — 5-heptene-2-one (30%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959^{8} (1935).

Rx. 793



3,5-heptadiene-2-one — 5-heptene-2-ol (30%)

Fischer and Wiedemann, Ann. 522, 1-16 (1936).

C.A. 30, 3780^{6} (1936).

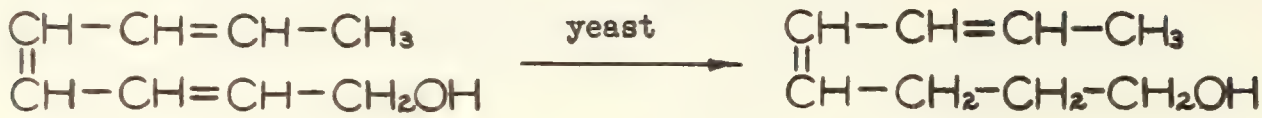
Rx. 794

2,4,6-octatrienal — 4,6-octadiene-1-ol

Fischer and Wiedemann, Ann. 522, 1-16 (1936).

C.A. 30, 3780[6] (1936).

Rx. 795

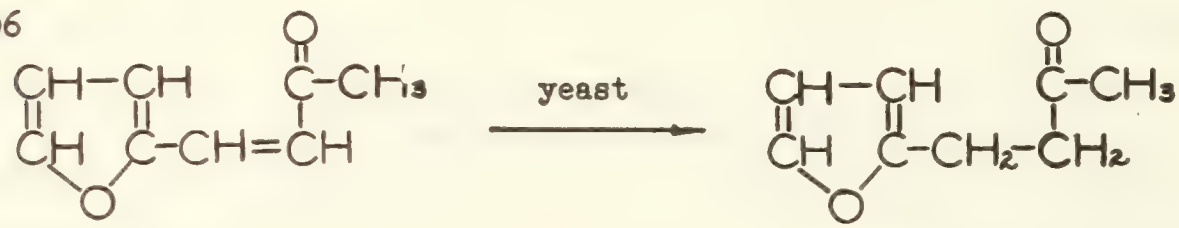


2,4,6-octatriene-1-ol — 4,6-octadiene-1-ol

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 796

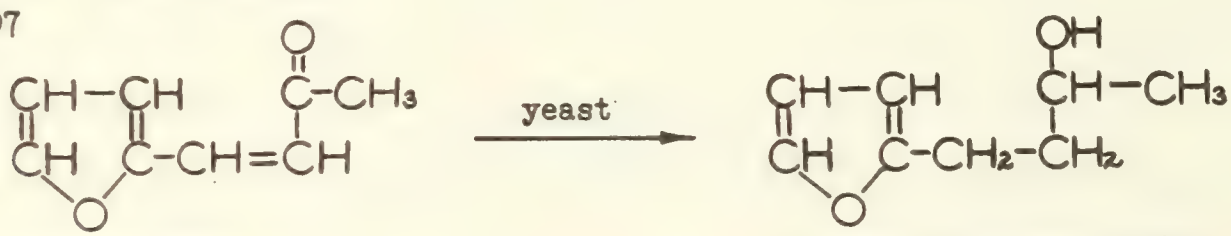


furfuralacetone — 4-furyl-2-butanone (22.6%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 797

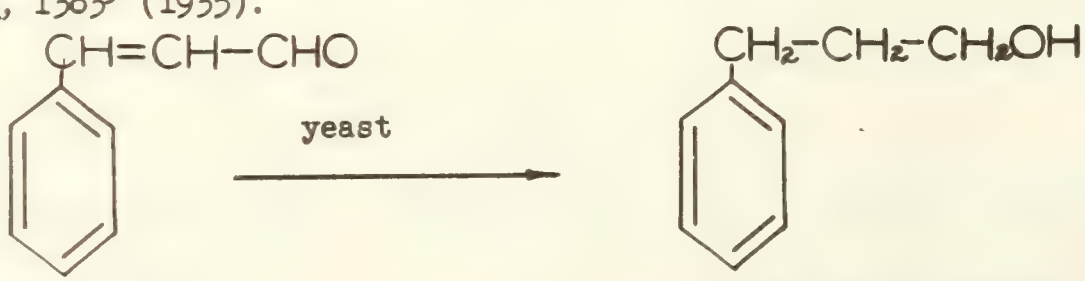


furfuralacetone — 4-furyl-2-butanol (5%)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 798

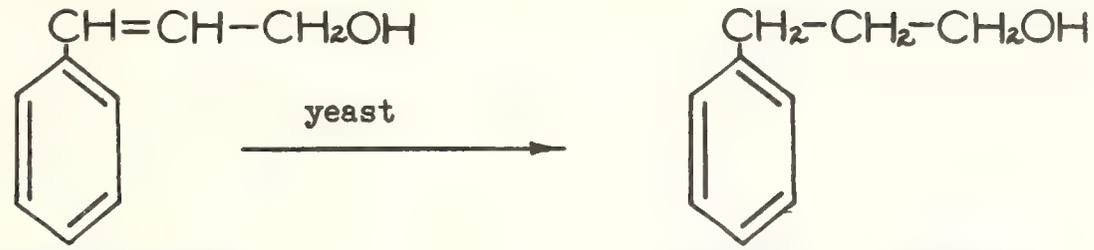


cinnamic aldehyde — 3-phenyl-1-propanol (17%)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 799



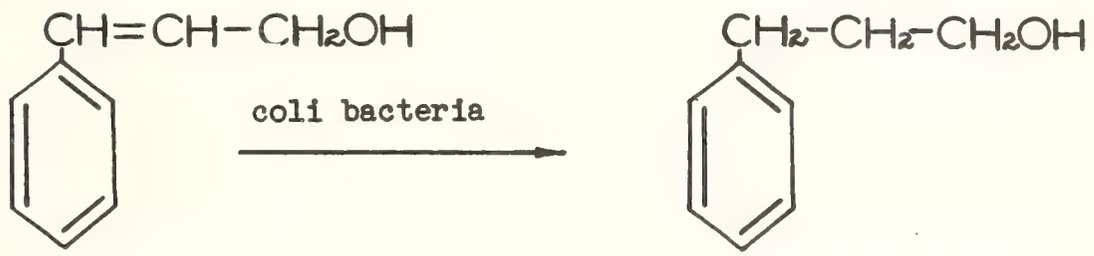
cinnamyl alcohol

3-phenyl-1-propanol (approx. 50%)

Fischer and Robertson, Ann. 529, 84-7 (1937).

C.A. 31, 5320[1] (1937).

Rx. 800



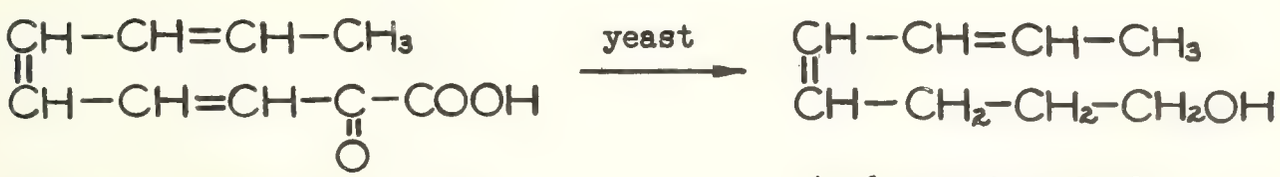
cinnamyl alcohol

3-phenyl-1-propanol (not over 3%)

Fischer and Wiedemann, Ann. 522, 1-16 (1936).

C.A. 30, 3780[6] (1936).

Rx. 801



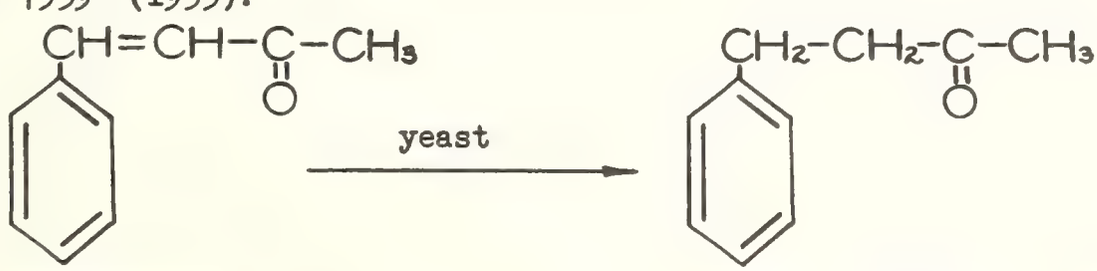
2-keto-3,5,7-nonatrienoic acid

4,6-octadiene-1-ol

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 802



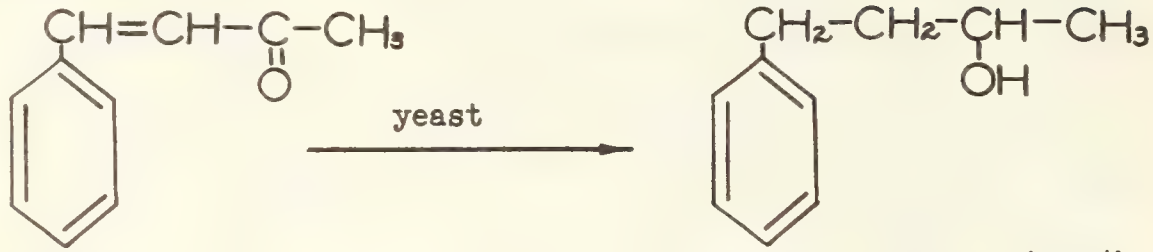
benzalacetone

4-phenyl-2-butanone (73%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 803

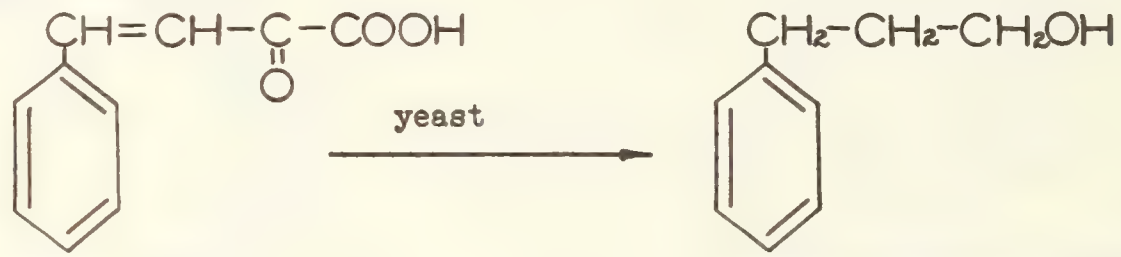


benzalacetone — 4-phenyl-2-butanol (3.3%)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 1383[9] (1935).

Rx. 804

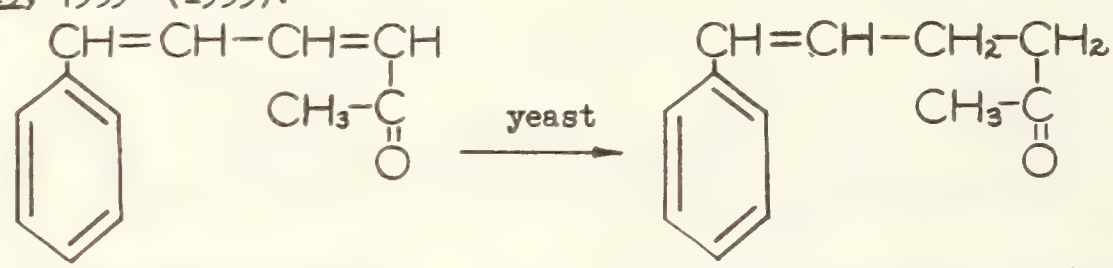


benzalpyruvic acid — 3-phenyl-1-propanol (75%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 805

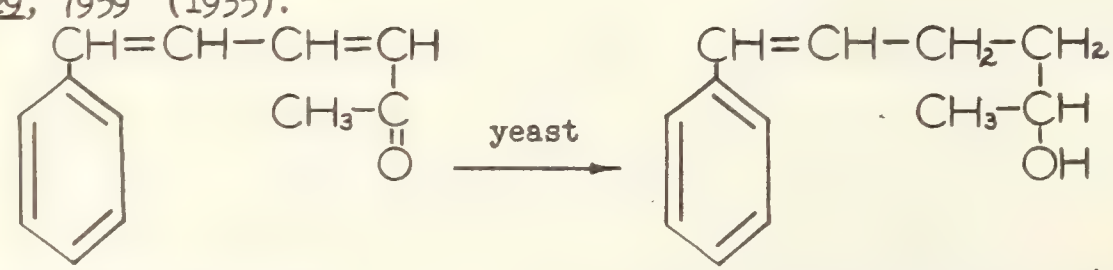


6-phenyl-3,5-hexadiene-2-one — 6-phenyl-5-hexene-2-one (24%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 7959[8] (1935).

Rx. 806

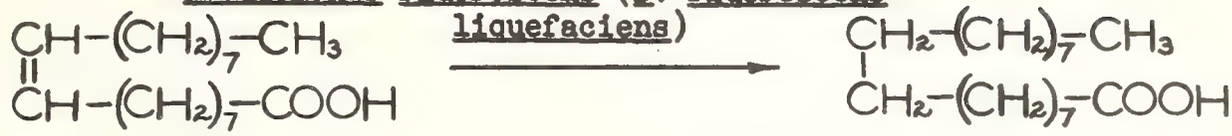


6-phenyl-3,5-hexadiene-2-one — 6-phenyl-5-hexene-2-ol (6%)

Schönbrunner, Biochem. Z. 304, 26-36 (1940).

C.A. 34, 4102[9] (1940).

Rx. 807

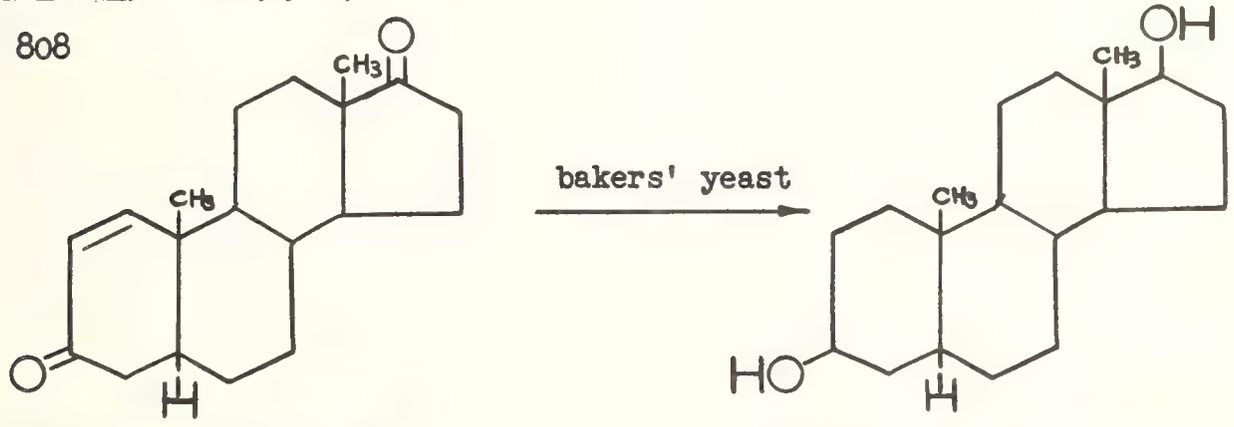


oleic acid (Na salt) → stearic acid (32-67%)

Butenandt et al., Ber. 73B, 818-20 (1940).

C.A. 35, 763[9] (1941).

Rx. 808

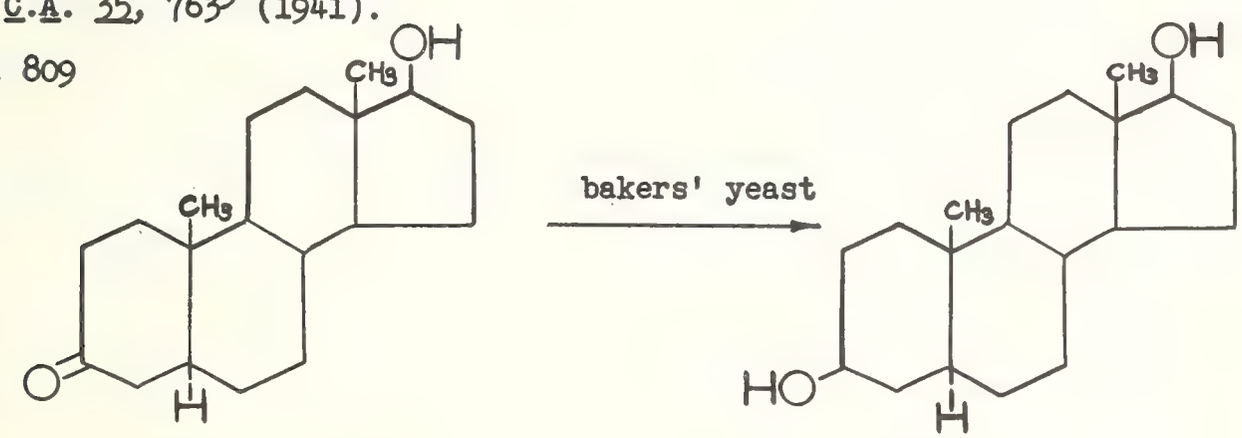


Δ^1-androstene-3,17-dione → isoandrostane-3β,17β-diol

Butenandt et al., Ber. 73B, 818-20 (1940).

C.A. 35, 763[9] (1941).

Rx. 809

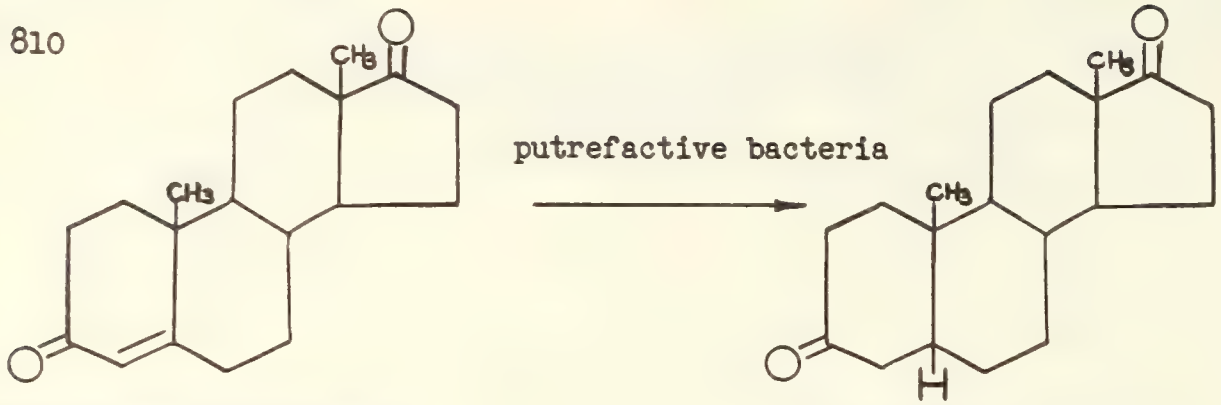


Δ^1-androstene-17β-ol-3-one → isoandrostane-3β,17β-diol

Mamoli and Schramm, Ber. 71B, 2083-6 (1938).

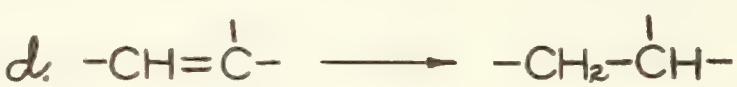
C.A. 33, 7146 (1939).

Rx. 810



Δ^4-androstene-3,17-dione — etiocholane-3,17-dione

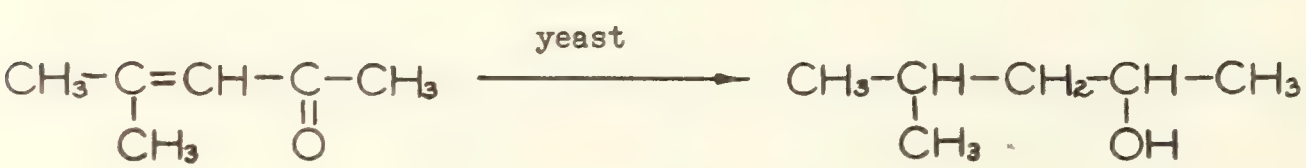
II. Reduction



Fischer and Wiedemann, Ann. 520, 52-70 (1935).

C.A. 29, 79598 (1935).

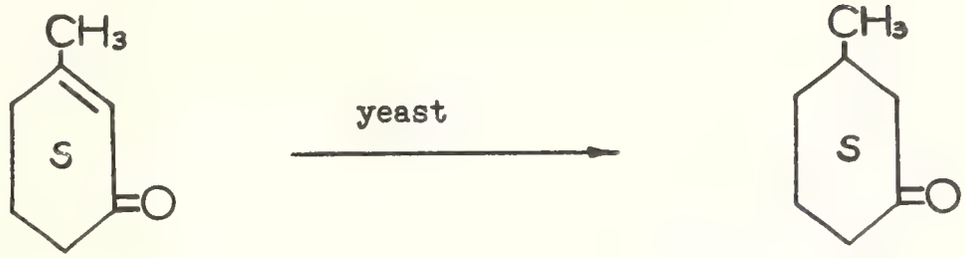
Rx. 811



mesityl oxide — 4-methyl-2-pentanol (6-11%) (methylisobutylcarbinol)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).
C.A. 29, 7959[8] (1935).

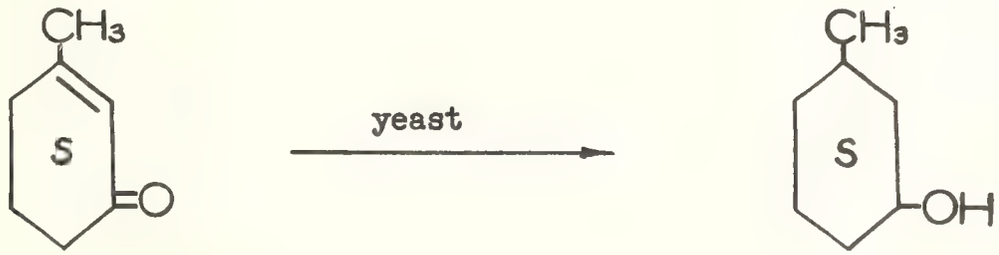
Rx. 812



3-methyl-2-cyclohexenone — 3-methylcyclohexanone (80%)

Fischer and Wiedemann, Ann. 520, 52-70 (1935).
C.A. 29, 7959[8] (1935).

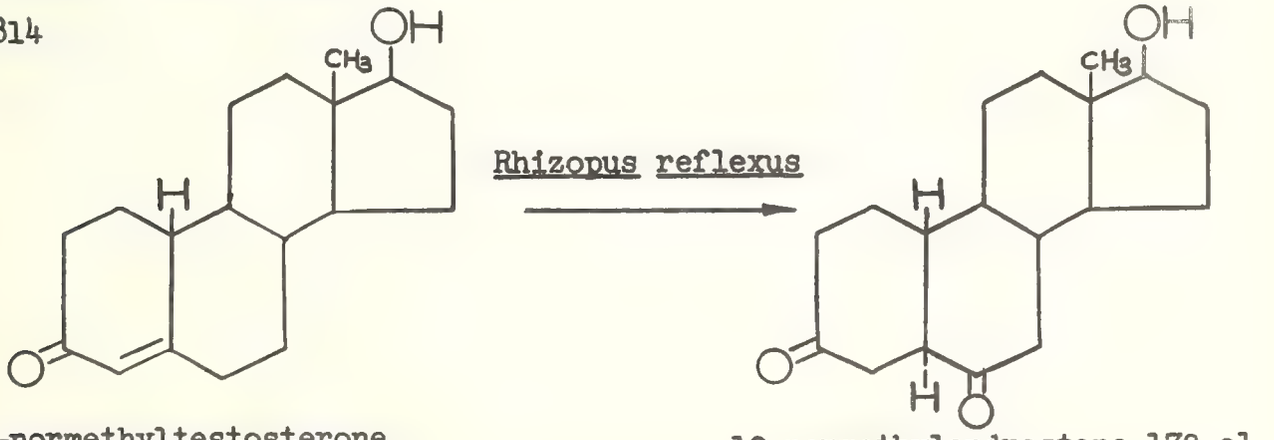
Rx. 813



3-methyl-2-cyclohexenone — 3-methylcyclohexanol (20%)

Murray and Peterson, U.S. 2,692,273 (Oct. 19, 1954).
C.A. 49, 11732b (1955).

Rx. 814

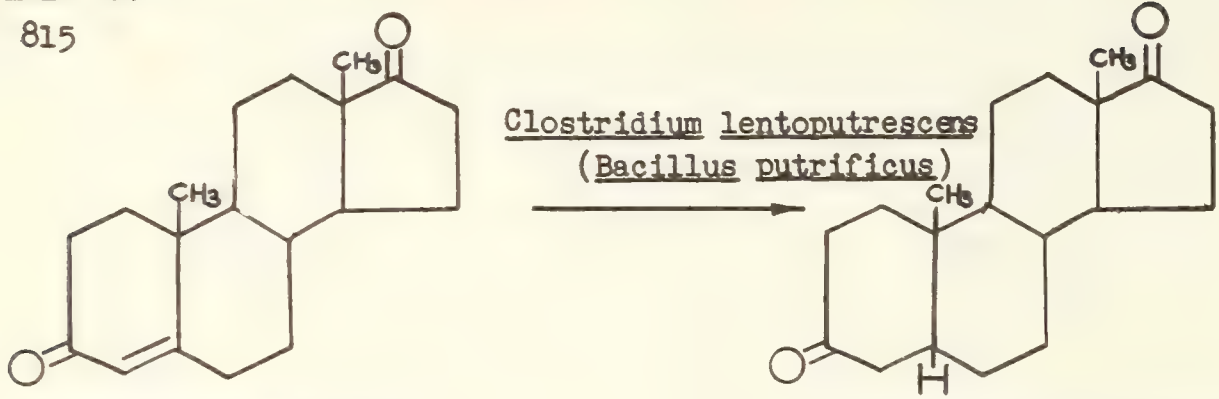


10-normethyltestosterone — 10-normethylandrostane-17β-ol-3,6-dione

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 1704[9] (1940).

Rx. 815



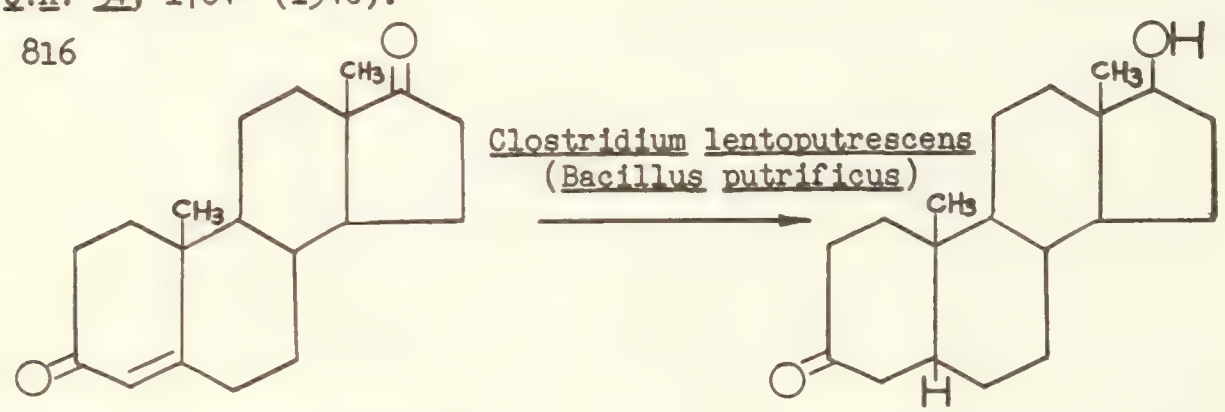
Δ^4-androstene-3,17-dione

etiocholane-3,17-dione
(70-80%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 1704[9] (1940).

Rx. 816



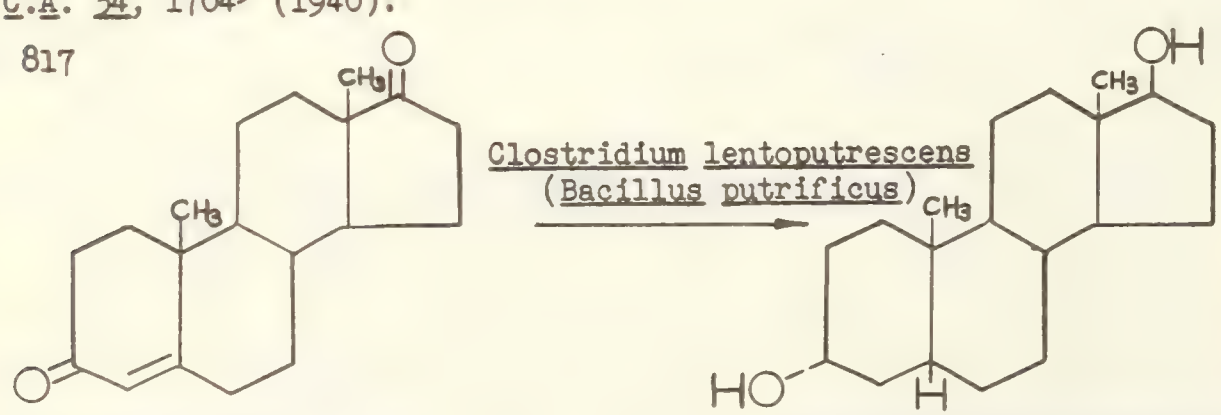
Δ^4-androstene-3,17-dione

etiocholane-17β-ol-3-one
(approx. 39%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 1704[9] (1940).

Rx. 817



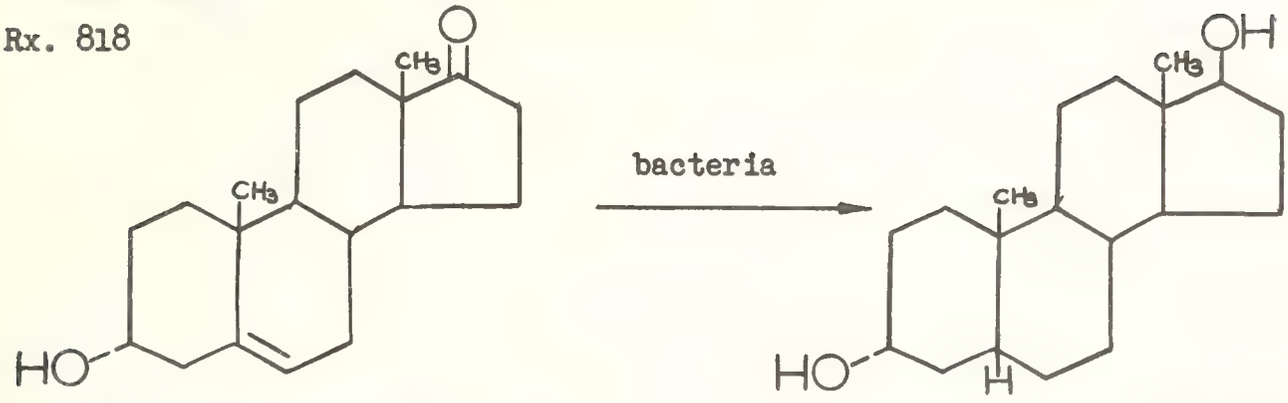
Δ^4-androstene-3,17-dione

epietiocholane-3α,17β-diol
(13%)

Schramm and Mamoli, Ber. 71B, 1322-3 (1938).

C.A. 32, 7987[3] (1938).

Rx. 818



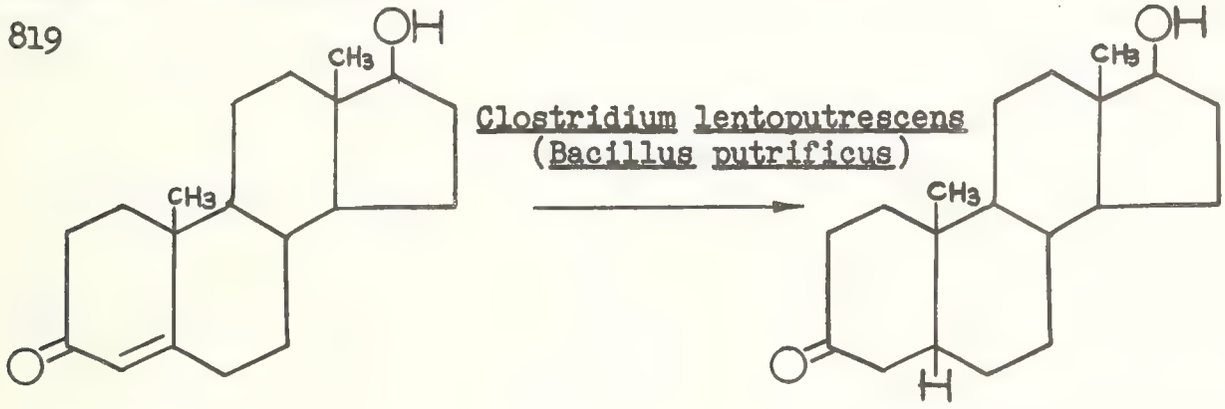
Δ^5-dehydroandrosterone

epietiocholane-3α,17β-diol

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 1704[9] (1940).

Rx. 819



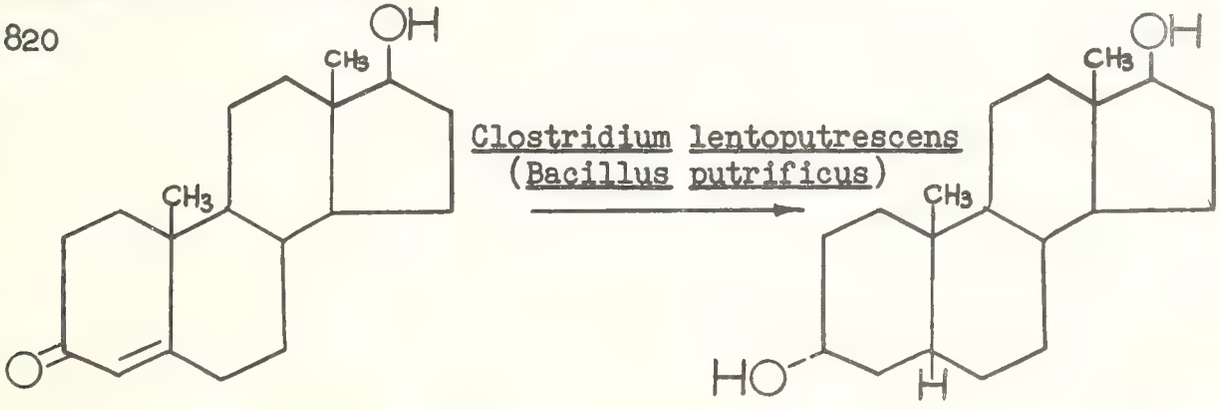
testosterone

etiocholane-17β-ol-3-one
(70-80%)

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939). See Ber. 71B, 2083 (1938).

C.A. 34, 1704[9] (1940).

Rx. 820



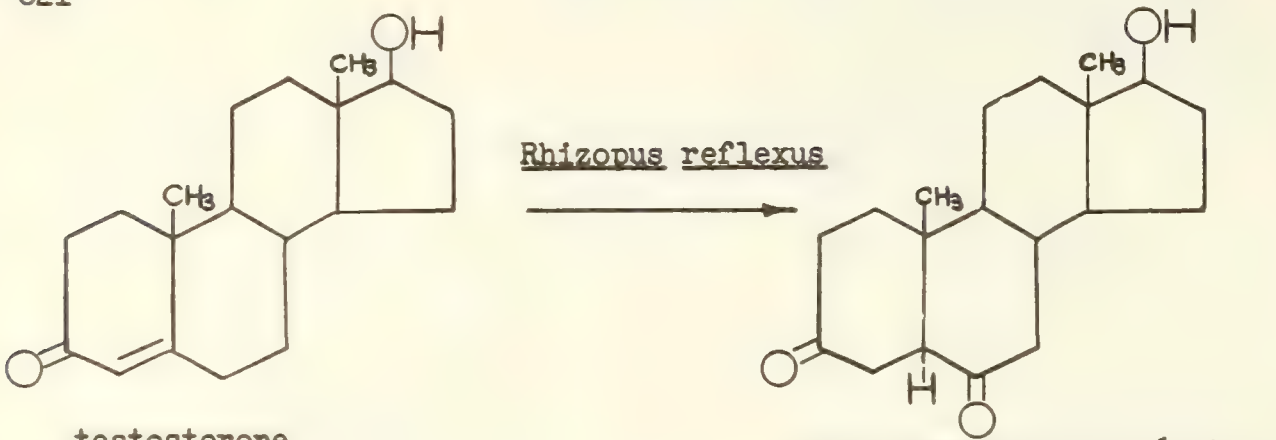
testosterone

epietiocholane-3α,17β-diol
(approx. 10%)

Eppstein et al., J. Am. Chem. Soc. 76, 3174-9 (1954). See U.S. 2,692,273 (Oct. 19, 1954).

C.A. 49, 9021i (1955).

Rx. 821



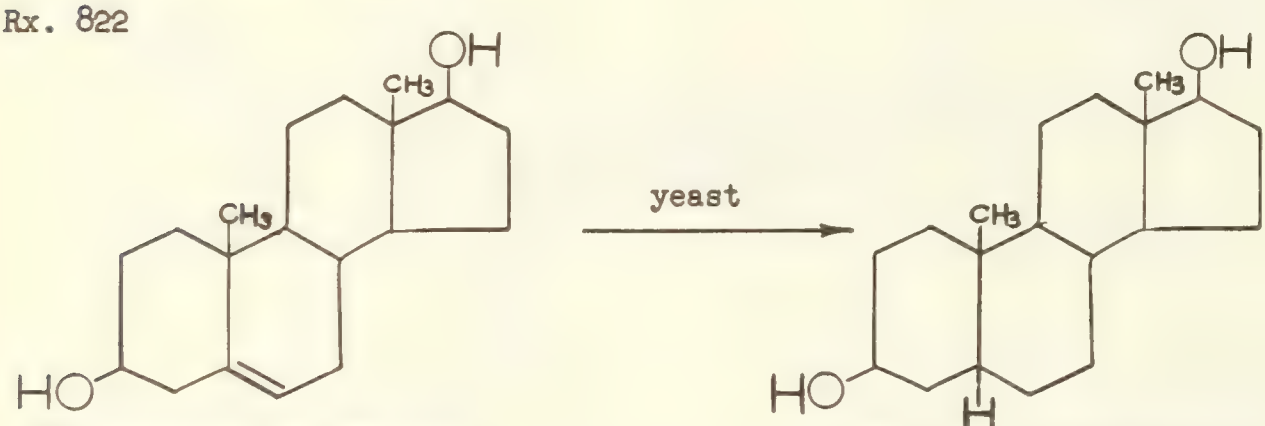
testosterone

androstane-17β-ol-3,6-dione

Mamoli, U.S. 2,186,906 (Jan. 9, 1940).

C.A. 34, 3436[8] (1940).

Rx. 822



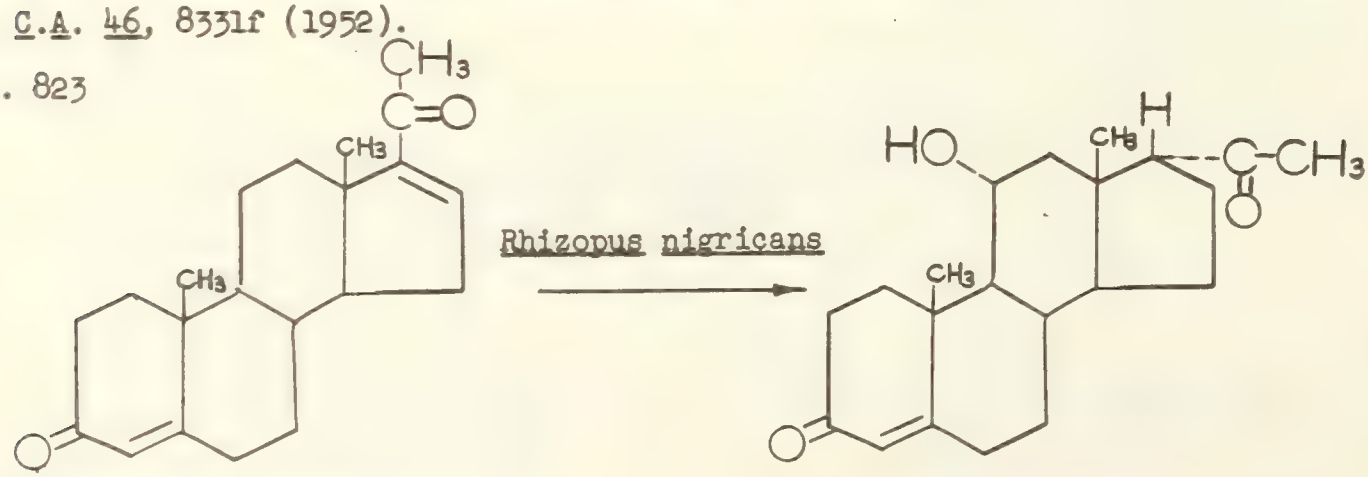
Δ^5-androstene-3β,17β-diol

isoandrostane-3β,17β-diol

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 823



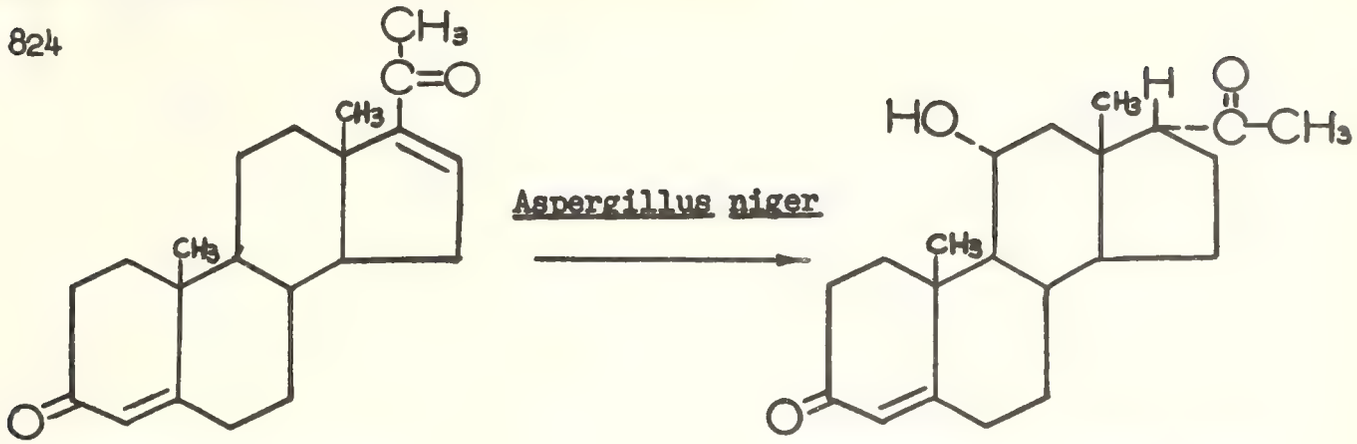
Δ^{16}-dehydroprogesterone

11α-hydroxy-17α-progesterone
(24%)

Murray and Peterson, U.S. 2,649,402 (Aug. 18, 1953).

C.A. reference not available.

Rx. 824



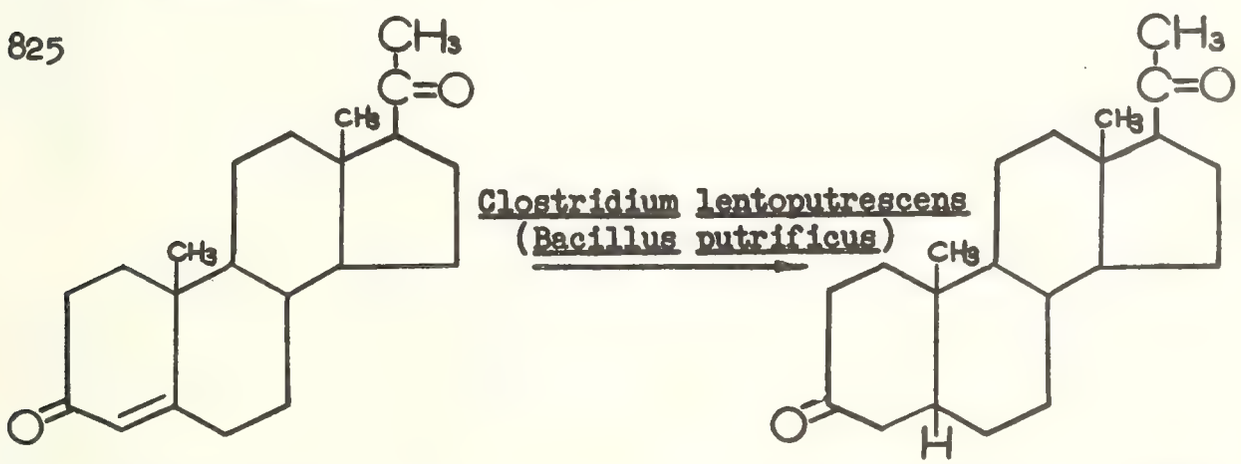
Δ^{16}-dehydroprogesterone

11α-hydroxy-17α-progesterone

Mamoli et al., Z. physiol. Chem. 261, 287-96 (1939).

C.A. 34, 1704[9] (1940).

Rx. 825



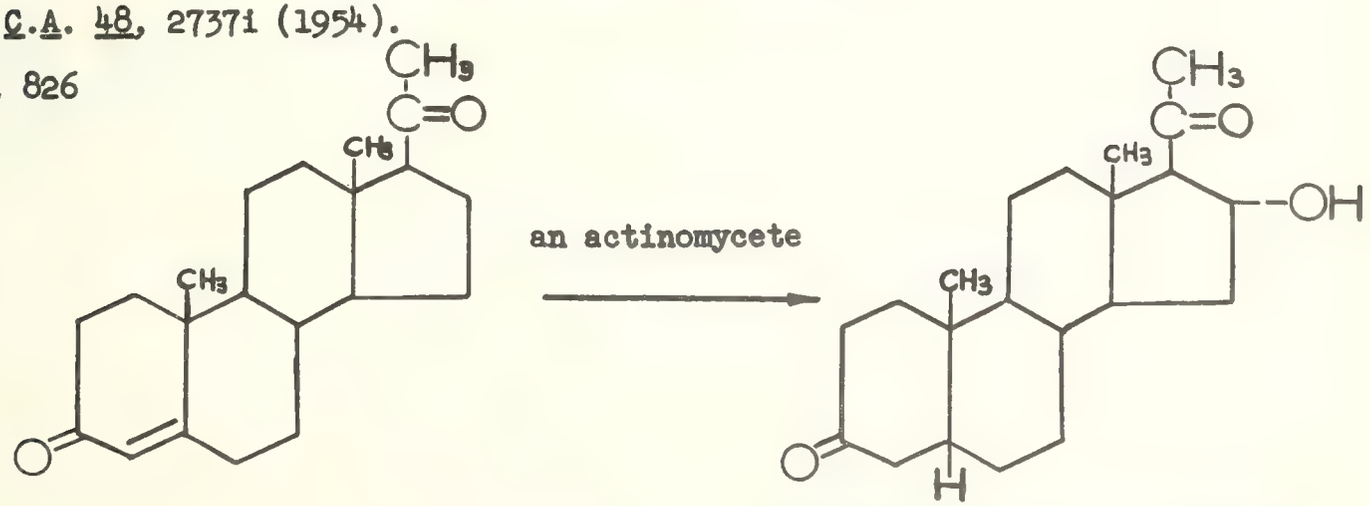
progesterone

pregnane-3,20-dione (86%)

Perlman et al., J. Am. Chem. Soc. 74, 2126 (1952).

C.A. 48, 2737i (1954).

Rx. 826



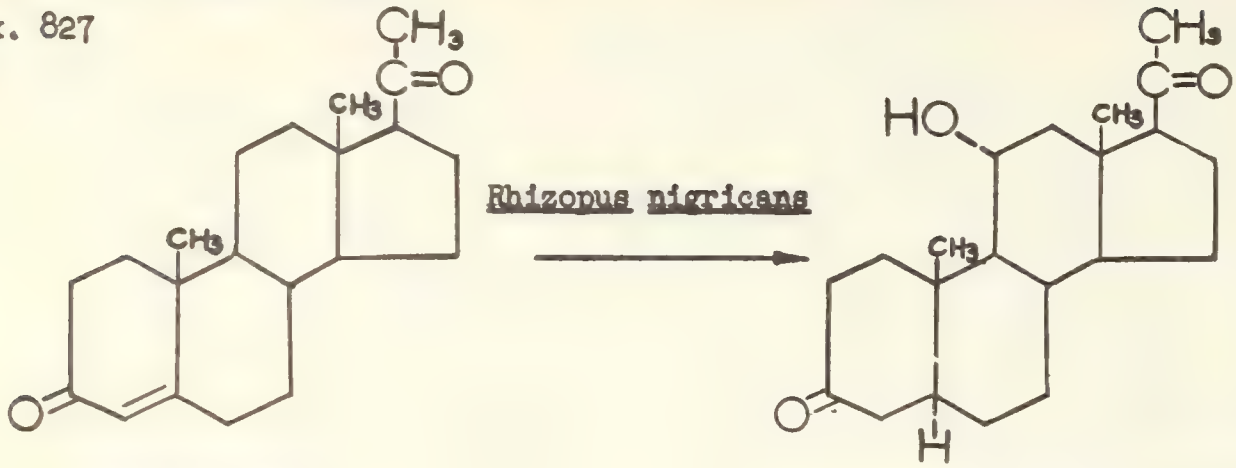
progesterone

16α-hydroxypregnane-3,20-dione

Peterson et al., J. Am. Chem. Soc. 74, 5933-6 (1952).

C.A. 47, 4426i (1953).

Rx. 827



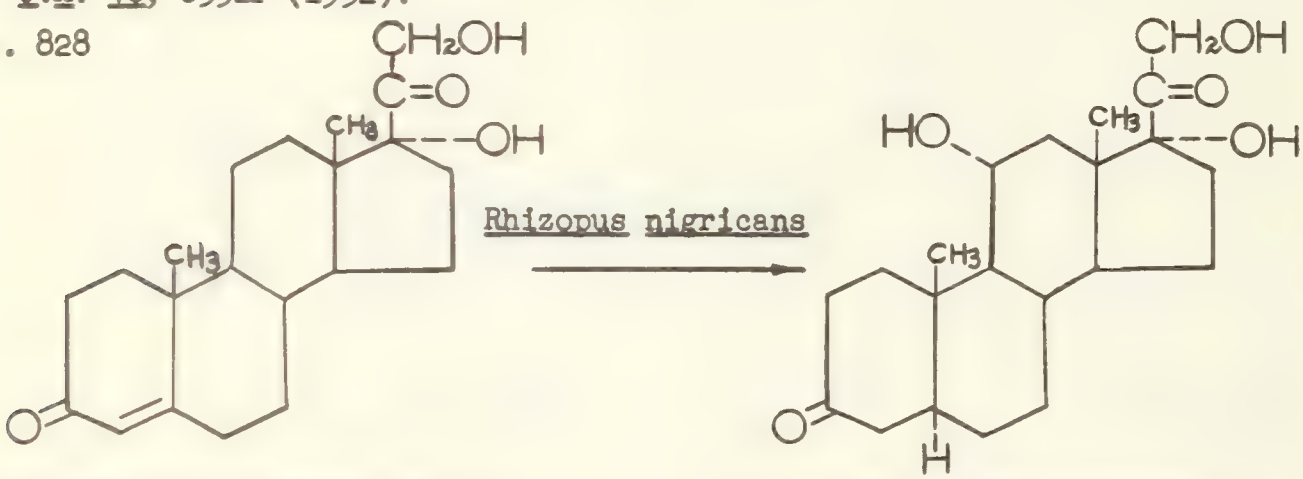
progesterone

11α-hydroxyallopregnane-3, 20-dione (5%)

Murray and Peterson, U.S. 2,602,769 (July 8, 1952).

C.A. 46, 8331f (1952).

Rx. 828



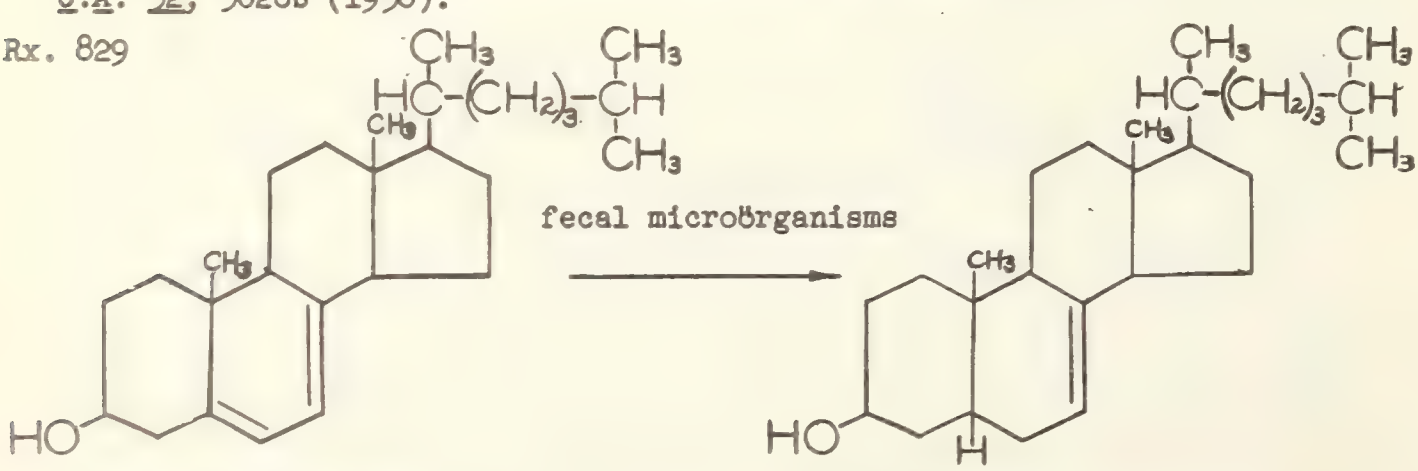
17α-hydroxy-11-desoxycorticosterone (Reichstein's Cpd. S)

11α,17α,21-trihydroxyallopregnane-3,20-dione (8.2%)

Coleman and Baumann, Arch. Biochem. Biophys. 72, 219-25 (1957).

C.A. 52, 3026b (1958).

Rx. 829

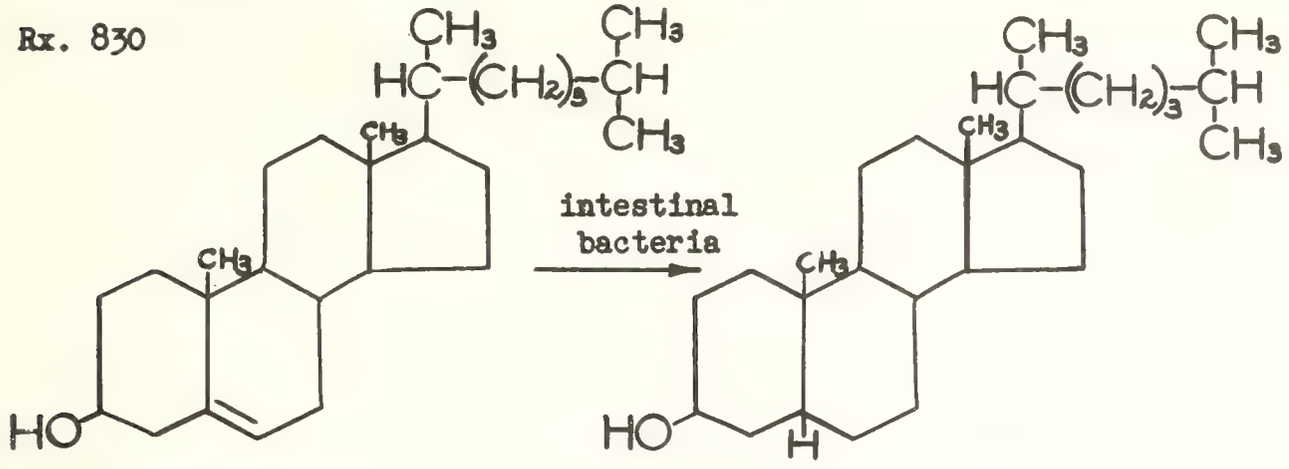


Δ^7-dehydrocholesterol

Δ^7-coprostenol

Baumgärtel and Zahn, Deut. Z. Verdauungs-u. Stoffwechselkrankh. 11, 257-66 (1951).
C.A. 46, 4052f (1952).

Rx. 830

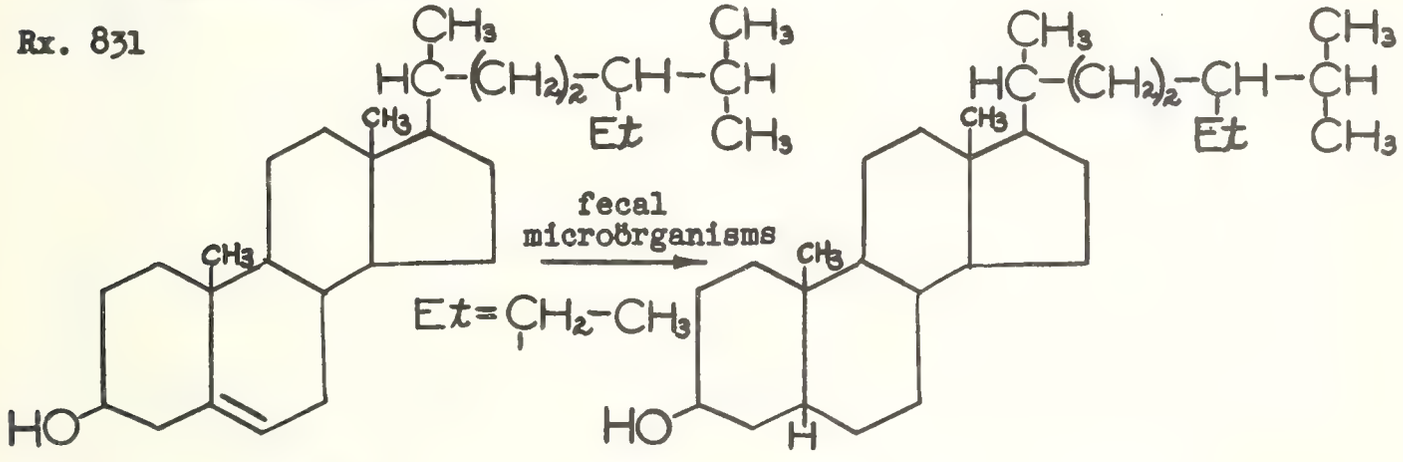


cholesterol

coprostanol
(coprosterol)

Coleman and Baumann, Arch. Biochem. Biophys. 72, 219-25 (1957).
C.A. 52, 3026b (1958).

Rx. 831



β-sitosterol
(24-ethylcholesterol)

coprositostanol
(24-ethylcoprostanol)

II. Reduction

$$\text{e. } -NO_2 \longrightarrow -NH_2$$

Neuberg and Welde, Biochem. Z. 62, 470-6 (1914).

C.A. 8, 2359[7] (1914).

Rx. 832

$$CH_3NO_2 \xrightarrow{\text{yeast}} CH_3NH_2$$

nitromethane — methylamine

Neuberg and Welde, Biochem. Z. 62, 470-6 (1914).

C.A. 8, 2359[7] (1914).

Rx. 833

$$CH_3-CH_2-NO_2 \xrightarrow{\text{yeast}} CH_3-CH_2-NH_2$$

nitroethane — ethylamine

Neuberg and Welde, Biochem. Z. 60, 472-9 (1914).

C.A. 8, 1746[5] (1914).

Rx. 834

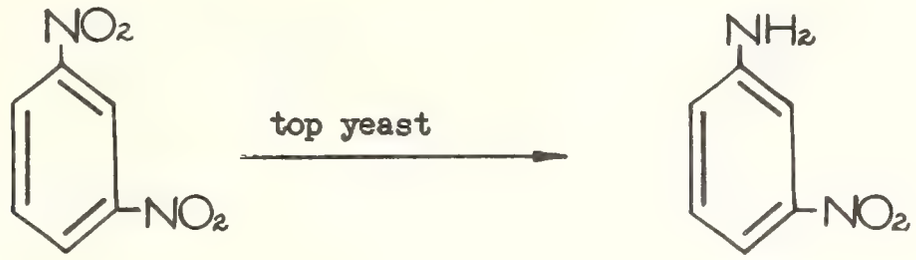
top yeast

nitrobenzene — aniline (approx. 29%)

Neuberg and Reinfurth, Biochem. Z. 138, 561-8 (1923).

C.A. 18, 1029 (1924).

Rx. 835

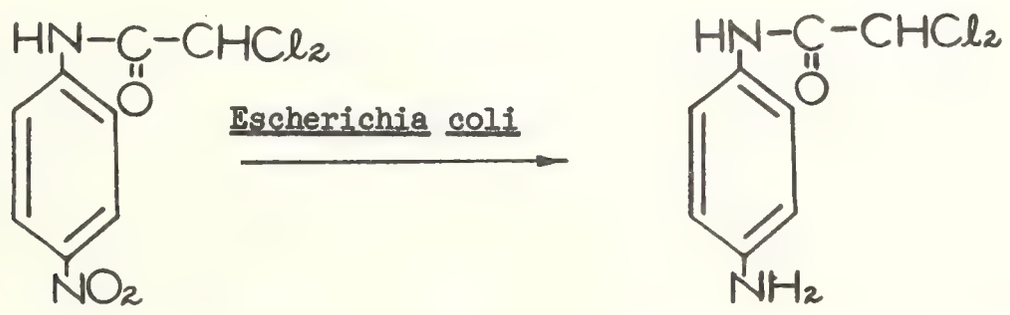


m-dinitrobenzene — m-nitroaniline

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 836



N-(p-nitrophenyl)-dichloro-acetamide — N-(p-aminophenyl)-dichloro-acetamide (49%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

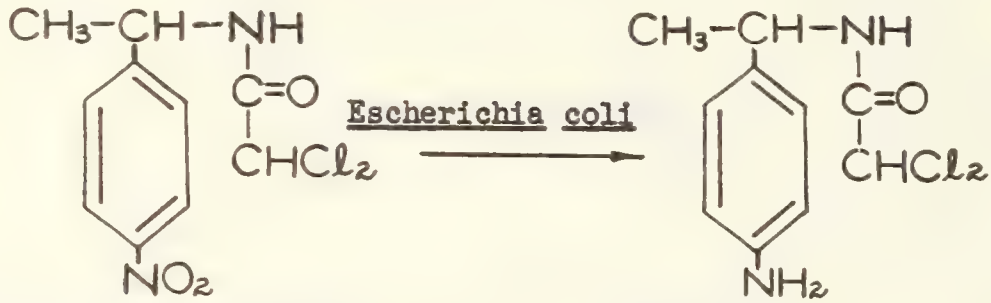
Rx. 837

N-(p-nitrobenzyl)-dichloro-acetamide — N-(p-aminobenzyl)-dichloro-acetamide (14%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 838



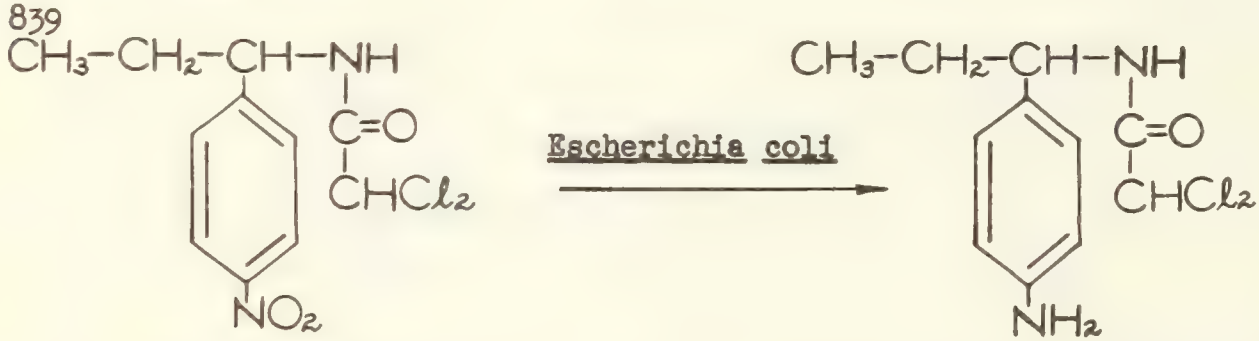
1-(p-nitrophenyl)-1-dichloro-acetamidoethane

1-(p-aminophenyl)-1-dichloro-acetamidoethane (7%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 839



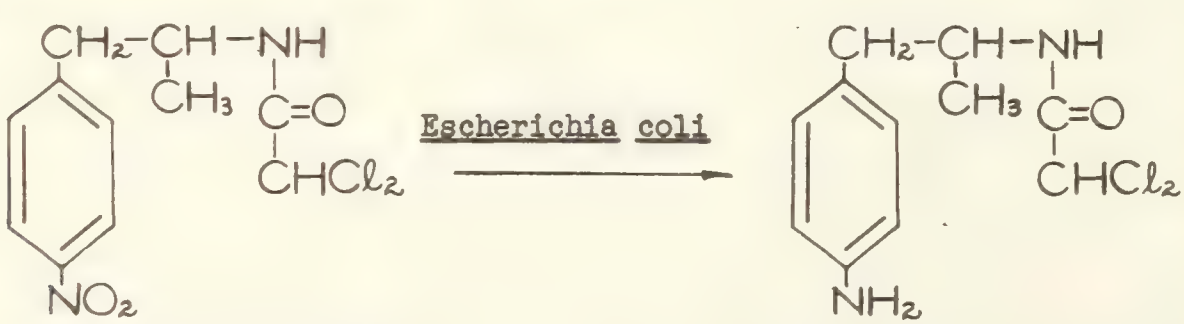
1-(p-nitrophenyl)-1-dichloro-acetamidopropane

1-(p-aminophenyl)-1-dichloro-acetamidopropane (8%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 840



1-(p-nitrophenyl)-2-dichloro-acetamidopropane

1-(p-aminophenyl)-2-dichloro-acetamidopropane (2.2%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 841

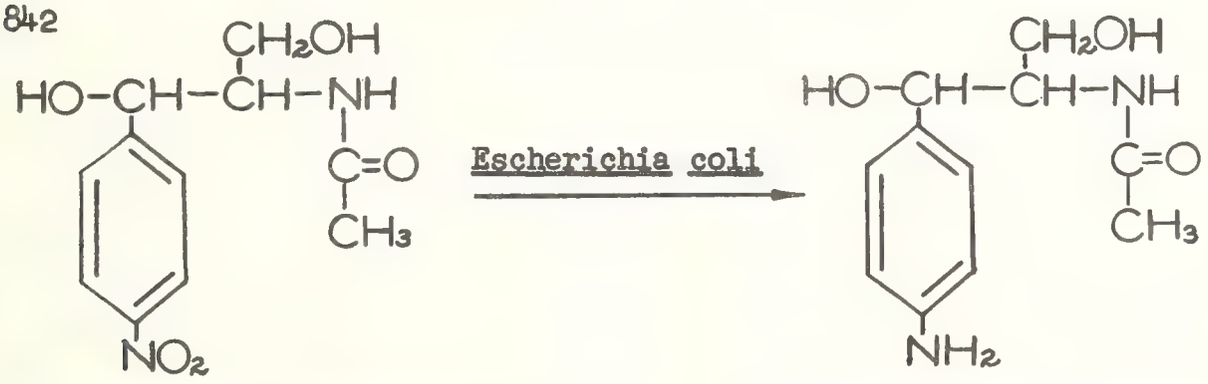
1-(p-nitrophenyl)-2-dichloro-acetamido ethanol

1-(p-aminophenyl)-2-dichloro-acetamido ethanol (26.4%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 842



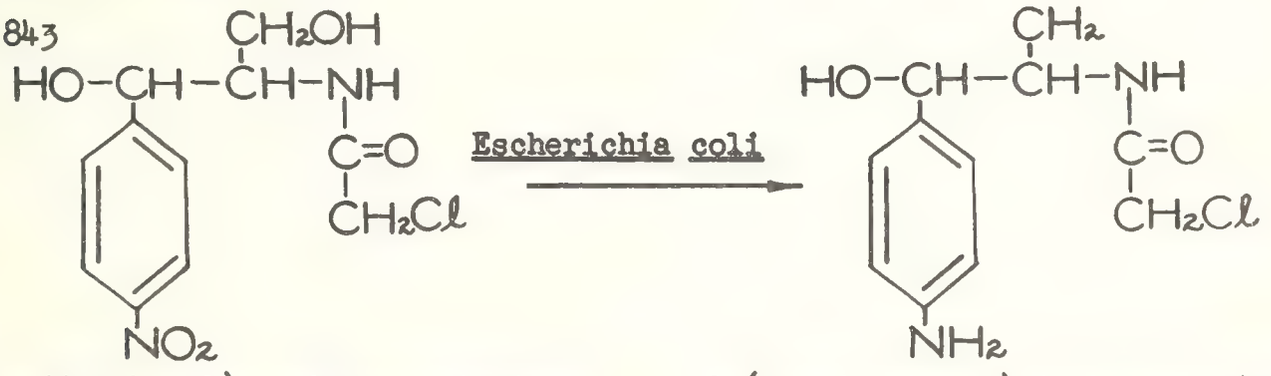
1-(p-nitrophenyl)-2-acetamido-1, 3-propanediol

1-(p-aminophenyl)-2-acetamido-1, 3-propanediol (20%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 843

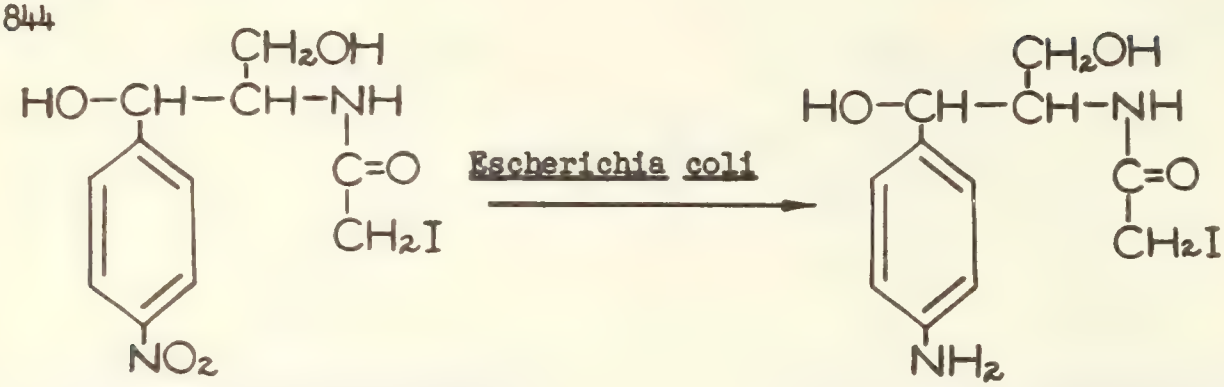


1-(p-nitrophenyl)-2-chloroacetamido-1, 3-propanediol

1-(p-aminophenyl)-2-chloroacetamido-1,3-propanediol (12%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).
C.A. 47, 5992d (1953).

Rx. 844

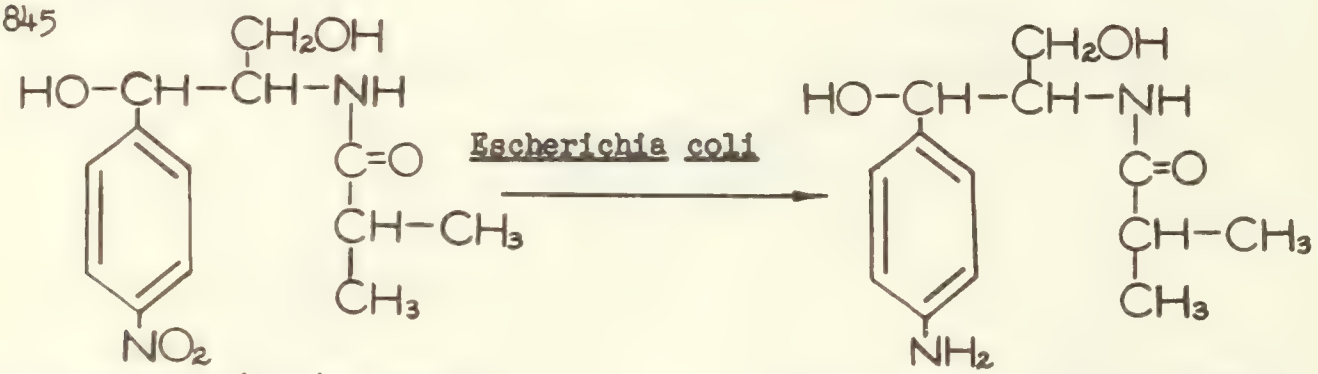


1-(p-nitrophenyl)-2-iodoacetamido-1, 3-propanediol

1-(p-aminophenyl)-2-iodoacetamido-1,3-propanediol (2.5%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).
C.A. 47, 5992d (1953).

Rx. 845

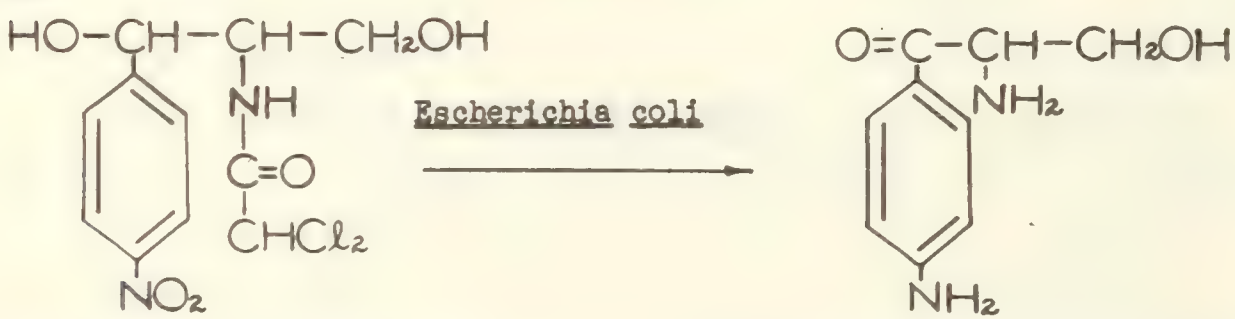


1-(p-nitrophenyl)-2-(α-methyl-propionamido)-1,3-propanediol

1-(p-aminophenyl)-2-(α-methyl-propionamido)-1,3-propanediol (17%)

Smith and Worrel, Arch. Biochem. 28, 232-41 (1950).
C.A. 45, 3031g (1951).

Rx. 846



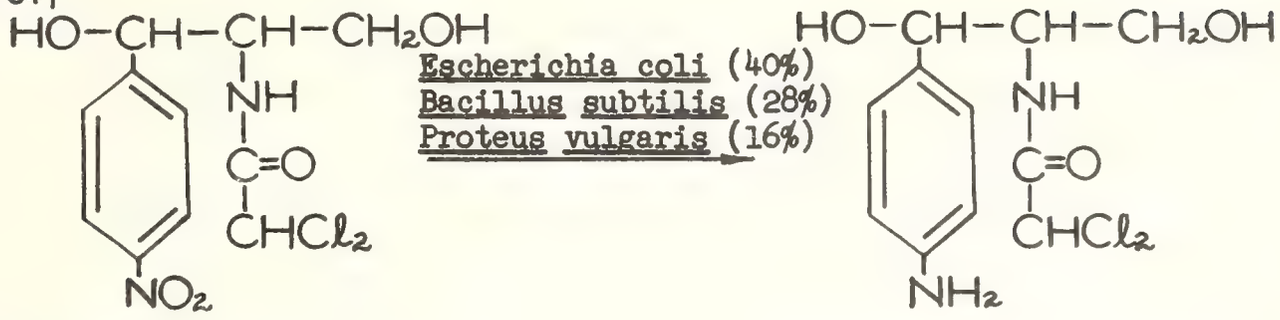
1-(p-nitrophenyl)-2-dichloro-acetamido-1,3-propanediol (chloramphenicol)

α-amino-β-hydroxy-p-amino-propiophenone

Smith and Worrel, Arch. Biochem. 24, 216-23 (1949).

C.A. 44, 2047a (1950).

Rx. 847



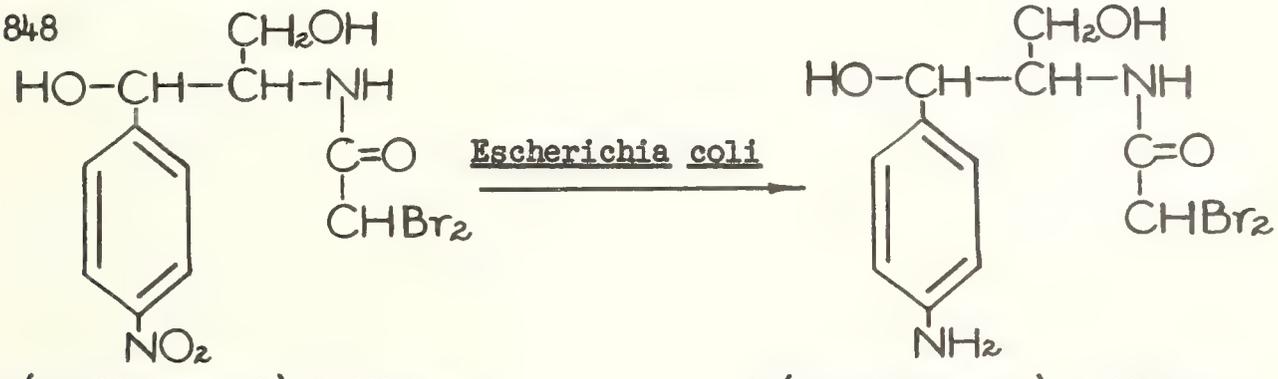
1-(p-nitrophenyl)-2-dichloro-acetamido-1,3-propanediol (chloramphenicol)

1-(p-aminophenyl)-2-dichloro-acetamido-1,3-propanediol

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 848



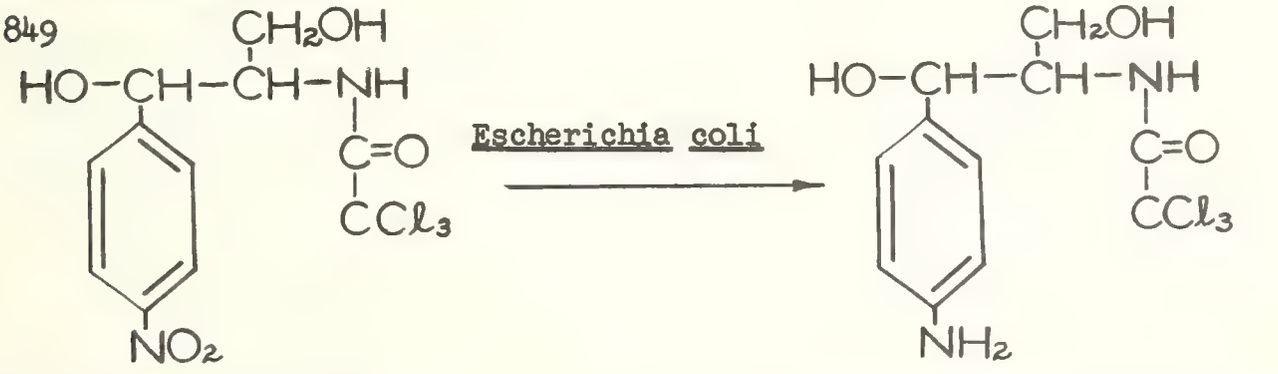
1-(p-nitrophenyl)-2-dibromo-acetamido-1,3-propanediol

1-(p-aminophenyl)-2-dibromo-acetamido-1,3-propanediol (14%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 849



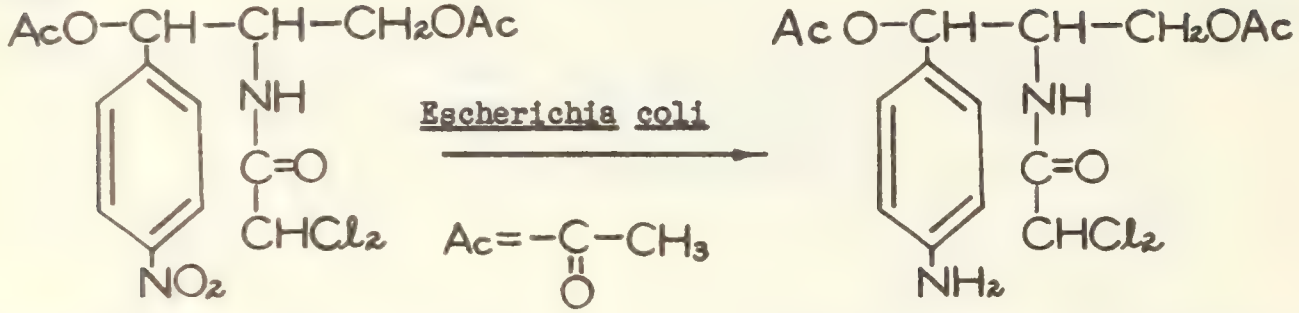
1-(p-nitrophenyl)-2-trichloro-acetamido-1,3-propanediol

1-(p-aminophenyl)-2-trichloro-acetamido-1,3-propanediol (7%)

Smith and Worrel, J. Bacteriol. 65, 313-17 (1953).

C.A. 47, 5992d (1953).

Rx. 850



1-(p-nitrophenyl)-2-dichloro-acetamido-O,O'-diacetyl-1,3-propanediol

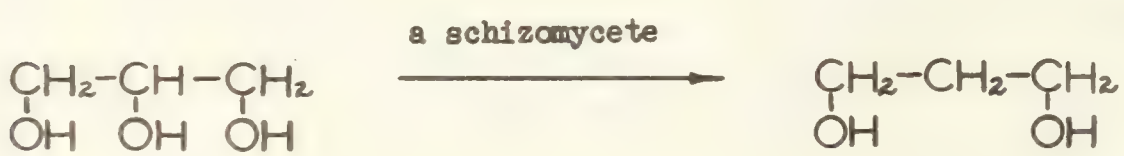
1-(p-aminophenyl)-2-dichloro-acetamido-O,O'-diacetyl-1,3-propanediol (5%)

II. Reduction

Freund, Monatsh. 2, 636-41 (1881).

Brit. C.A. 42 [i], 156 (1882).

Rx. 851



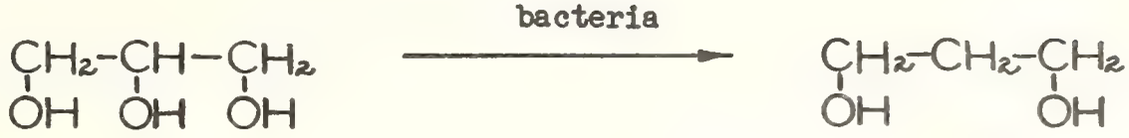
glycerol

trimethylene glycol (27%)

Noyes and Watkins, J. Am. Chem. Soc. 17, 890-1 (1895).

Brit. C.A. 70 [i], 114 (1896).

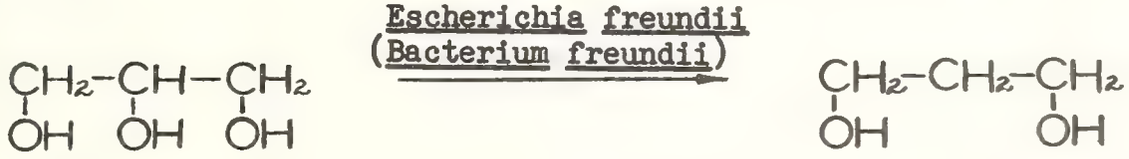
Rx. 852



glycerol → trimethylene glycol (38%)

Braak, "Onderzoekingen over Vergisting van Glycerine." Thesis, Delft (1928). See Werkman and Gillen, J. Bacteriol. 23, 170 (1932).

Rx. 853

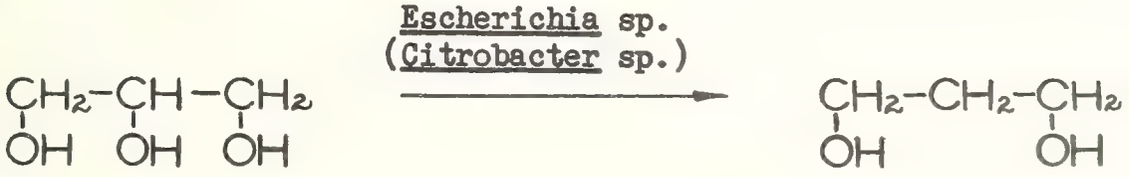


glycerol → trimethylene glycol

Werkman and Gillen, J. Bacteriol. 23, 167-82 (1932).

C.A. 26, 2761[8] (1932).

Rx. 854

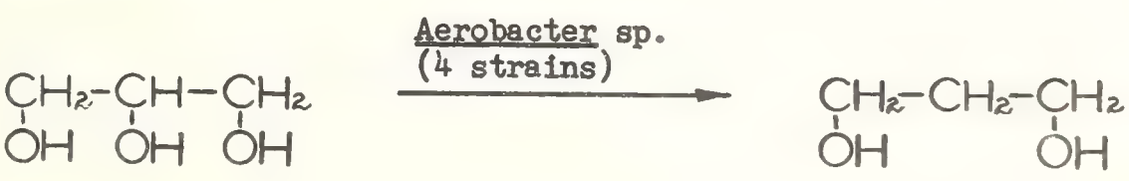


glycerol → trimethylene glycol

Mickelson and Werkman, Enzymologia 8, 252-6 (1940).

C.A. 34, 6969[2] (1940).

Rx. 855

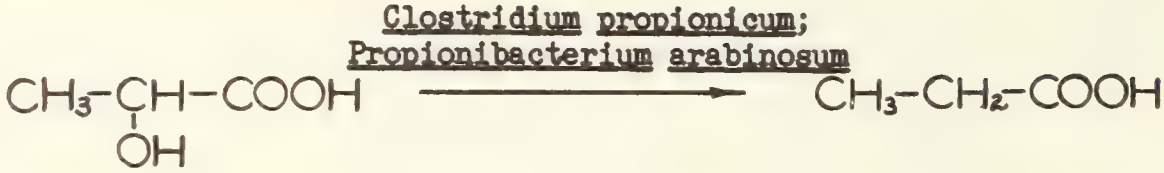


glycerol → trimethylene glycol (45%)

Leaver et al., J. Bacteriol. 70, 521-30 (1955).

C.A. 50, 2738c (1956).

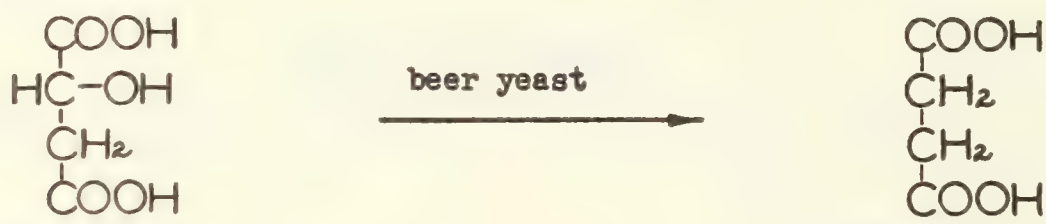
Rx. 856



lactic acid — propionic acid

Liebig, Ann. 70, 104-7; 363-6 (1849). See Houben, 3rd ed. Vol. II, 228 (1925).

Rx. 857

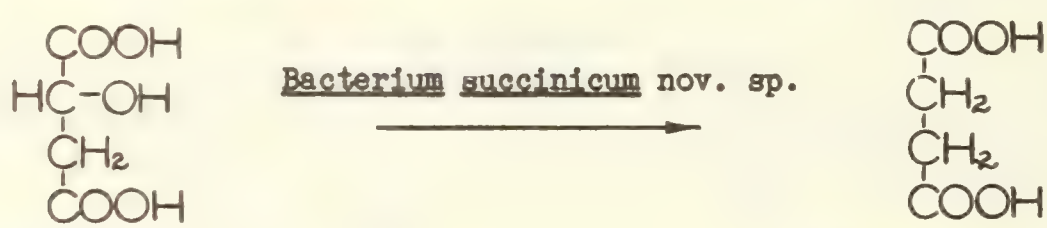


malic acid — succinic acid

Sakaguchi and Tada, Zentr. Bakt. Parasitenk. II Abt. 101, 341-54 (1940).

C.A. 34, 4105[2] (1940).

Rx. 858

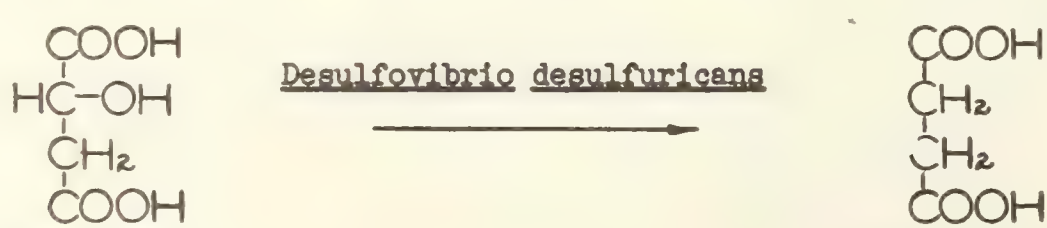


l-malic acid — succinic acid (25%)

Grossman and Postgate, J. Gen. Microbiol. 12, 429-45 (1955).

C.A. 49, 14882d (1955).

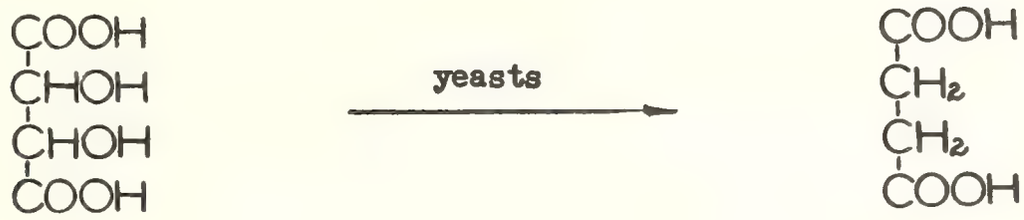
Rx. 859



malic acid — succinic acid

Bernhauer, "Garungschemisches Praktikum," Berlin (1939). 2nd ed., J. Springer, 317 pp.
C.A. 33, 5590^5 (1939).

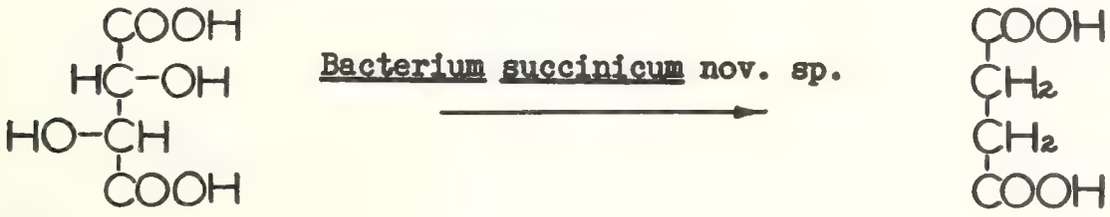
Rx. 860



tartaric acid — succinic acid

Sakaguchi and Tada, Zentr. Bakt. Parasitenk. II Abt. 101, 341-54 (1940).
C.A. 34, 4105^2 (1940).

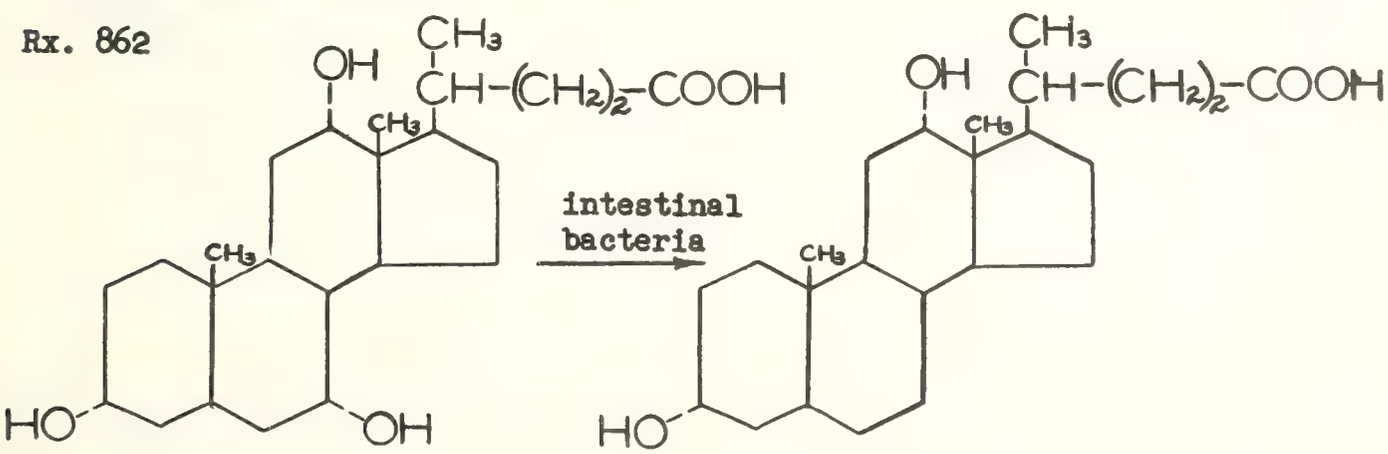
Rx. 861



d-tartaric acid — succinic acid (27-28.7%)

Baumgärtel and Zahn, Deut. Z. Verdauungs-u. Stoffwechselkrankh. 11, 257-66 (1951).
C.A. 46, 4052f (1952).

Rx. 862



cholic acid — desoxycholic acid (3α,12α-dihydroxycholanic acid)

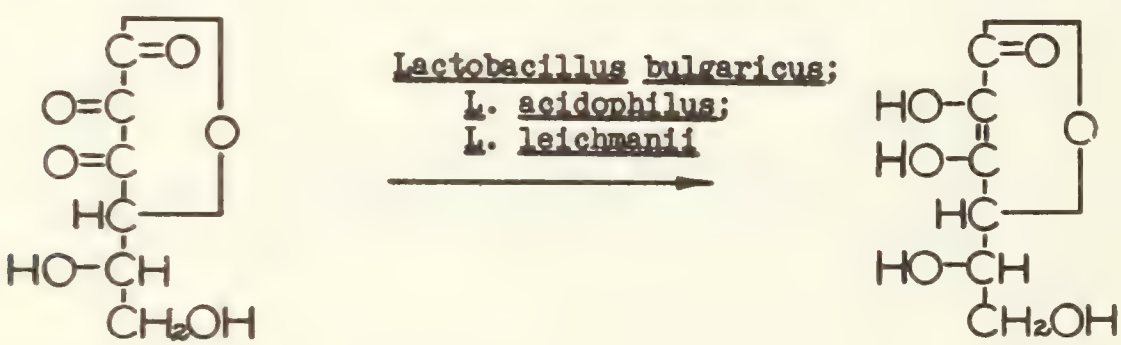
II. Reduction

g.

Tkachenko, Biokhimiya 1, 579-82 (1936).

C.A. 31, 7461[5] (1937).

Rx. 863



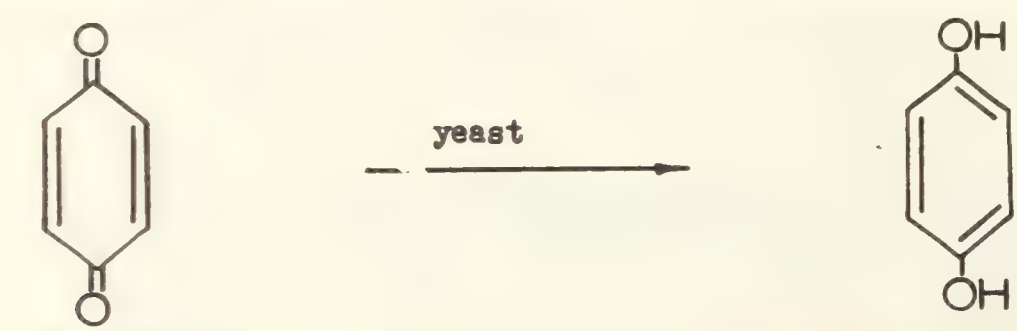
dehydroascorbic acid

L-ascorbic acid

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).

C.A. 21, 2013[8] (1927).

Rx. 864

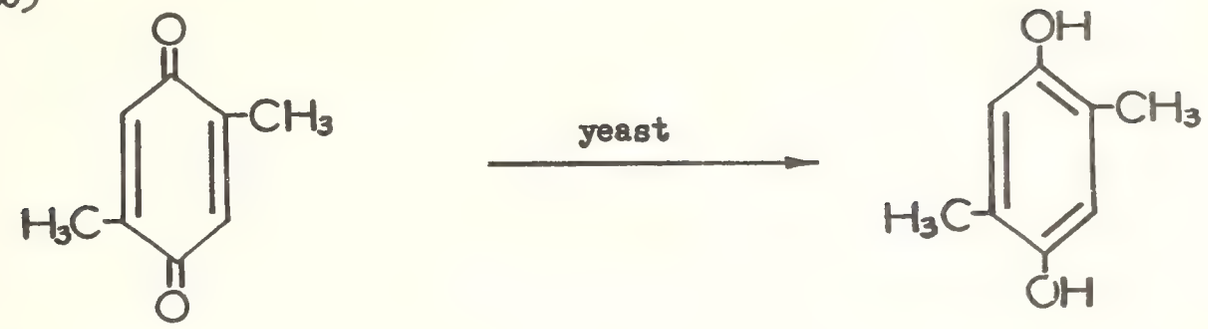


quinone
(benzoquinone)

hydroquinone (45%)

Neuberg and Simon, Biochem. Z. 171, 256-60 (1926).
C.A. 20, 3308[2] (1926).

Rx. 865

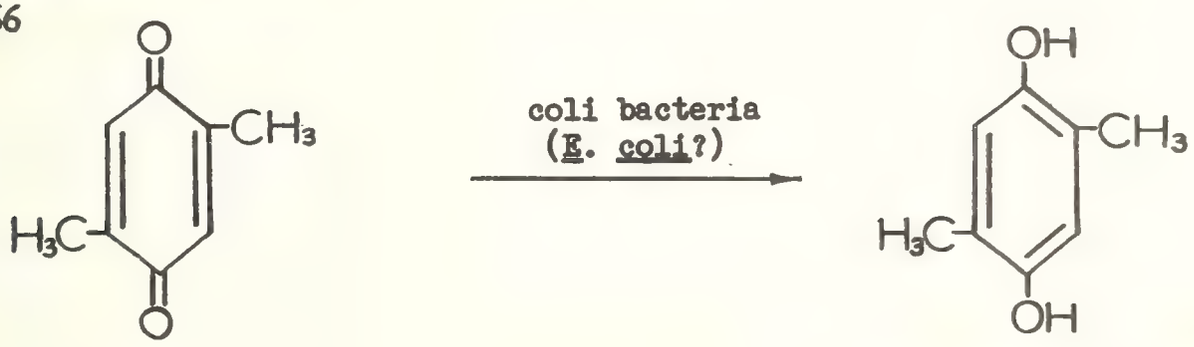


p-xyloquinone

p-xylohydroquinone (85-93%)

Neuberg and Simon, Biochem. Z. 190, 226-31 (1927).
C.A. 22, 1991[1] (1928).

Rx. 866

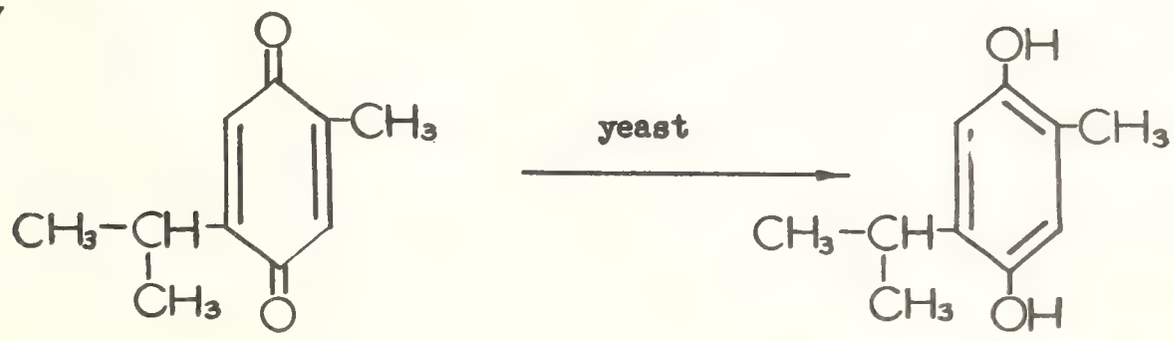


p-xyloquinone

p-xylohydroquinone (92%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).
C.A. 21, 2013[8] (1927).

Rx. 867



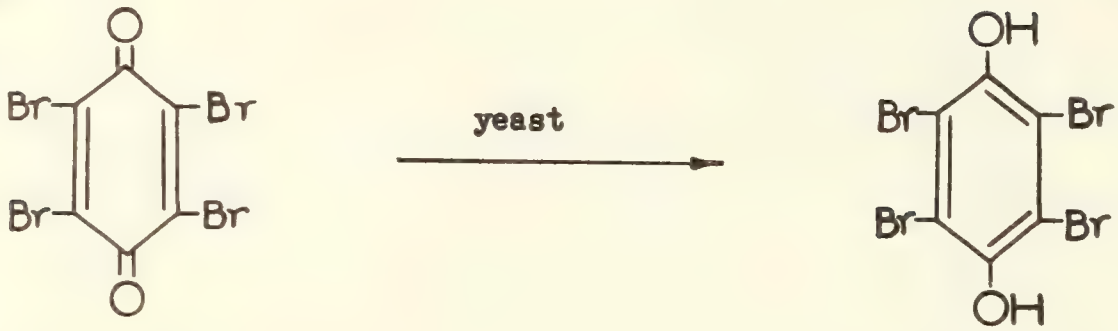
thymoquinone

2-methyl-5-isopropylhydroquinone (59%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).

C.A. 21, 2013[8] (1927).

Rx. 868



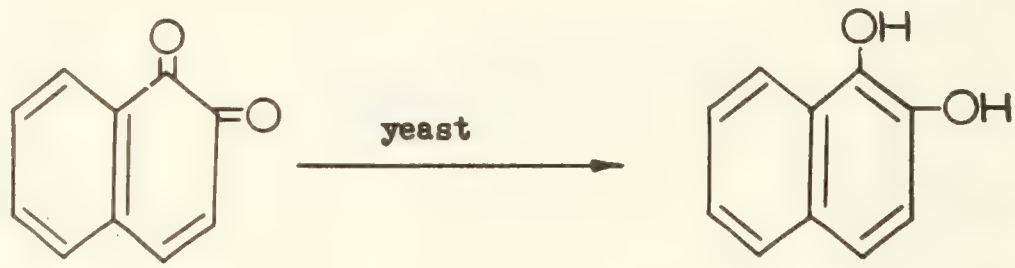
bromanil
(tetrabromobenzoquinone)

tetrabromohydroquinone
(20%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).

C.A. 21, 2013[8] (1927).

Rx. 869



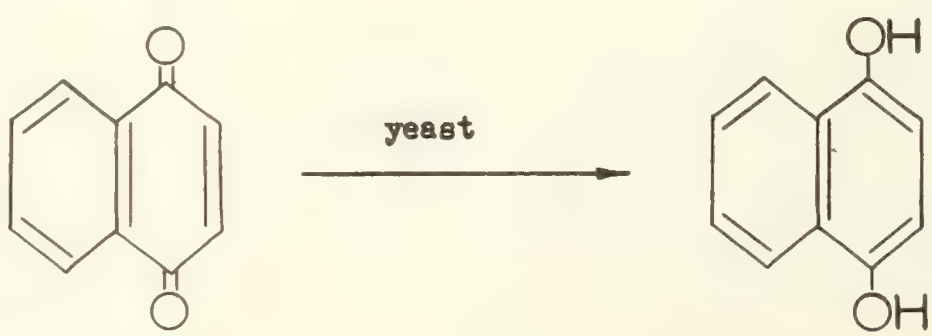
α,β-naphthoquinone

1,2-dihydroxynaphthalene
(α,β-naphthohydroquinone) (13.5%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).

C.A. 21, 2013[8] (1927).

Rx. 870

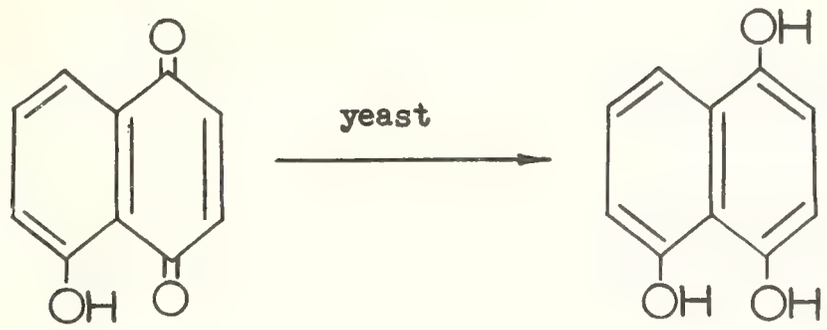


1,4-naphthoquinone

1,4-naphthohydroquinone
(1,4-dihydroxynaphthalene) (65%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).
C.A. 21, 2013[8] (1927).

Rx. 871

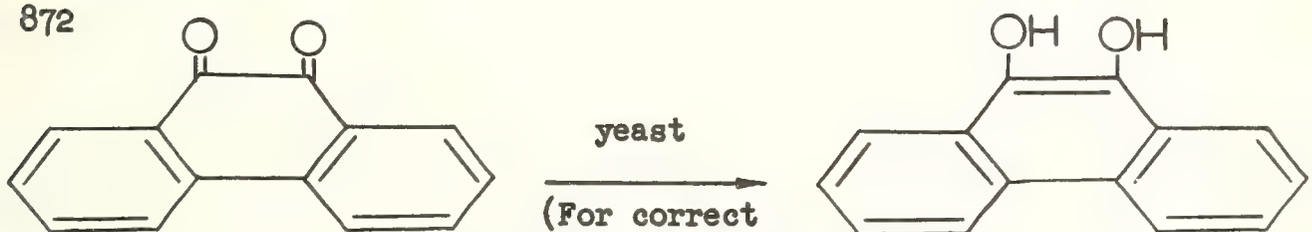


α-juglone
(5-hydroxy-1,4-naphthoquinone)

α-hydrojuglone
(1,4,5-trihydroxynaphthalene)(40%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).
C.A. 21, 2013[8] (1927).

Rx. 872



(For correct structure, see "Elsevier's Encyclopedia of Org. Chem." Vol. 13, 848.)

9,10-phenanthroquinone

9,10-phenanthrohydroquinone
(9%)

II. Reduction

h. $R-S-S-R \longrightarrow R-SH$

Blackburn and Challenger, J. Chem. Soc. 1872-8 (1938).
C.A. 33, 1265[3] (1939).

Rx. 873

$$CH_3-S-S-CH_3 \xrightarrow[(\text{Penicillium brevicaule})]{\text{Scopulariopsis brevicaulis}} CH_3SH$$

dimethyl disulfide — methyl mercaptan

Neuberg and Schwenk, Biochem. Z. 71, 118-21 (1915).
C.A. 9, 3058[6] (1915).

Rx. 874

$$CH_3-CH_2-S-S-CH_2-CH_3 \xrightarrow{\text{bottom yeast}} CH_3-CH_2SH$$

diethyldisulfide — ethanethiol (4%) (ethyl mercaptan)

Challenger and Rawlings, J. Chem. Soc. 868-75 (1937).
C.A. 31, 5321[4] (1937).

Rx. 875

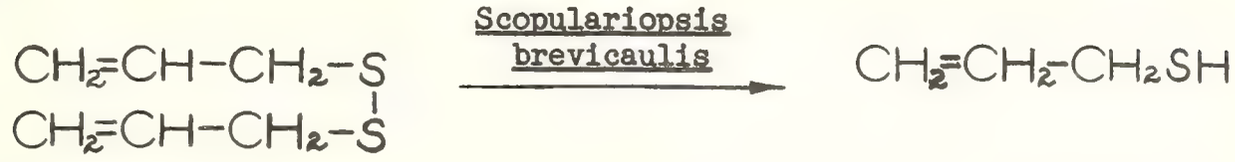
$$CH_3-CH_2-S-S-CH_2-CH_3 \xrightarrow[(\text{Penicillium brevicaule})]{\text{Scopulariopsis brevicaulis}} CH_3-CH_2SH$$

diethyldisulfide — ethyl mercaptan

Challenger and Greenwood, Biochem. J. 44, 87-91 (1949).

C.A. 43, 6286f (1949).

Rx. 876

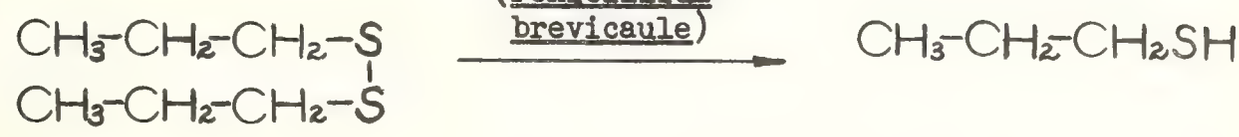


diallyl disulfide — allyl mercaptan

Challenger and Rawlings, J. Chem. Soc. 868-75 (1937).

C.A. 31, 5321[4] (1937).

Rx. 877

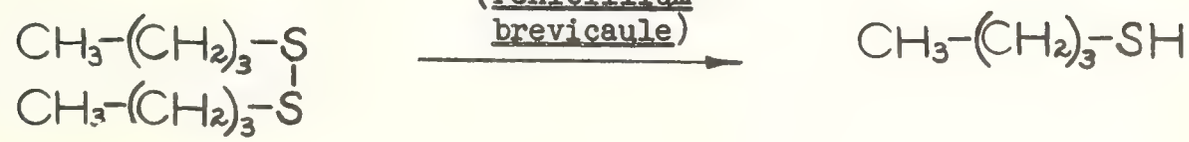


di-n-propyl disulfide — n-propyl mercaptan

Blackburn and Challenger, J. Chem. Soc. 1872-8 (1938).

C.A. 33, 1265[3] (1939).

Rx. 878

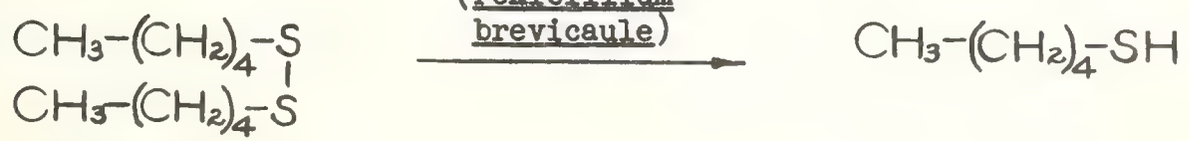


di-n-butyl disulfide — n-butyl mercaptan

Blackburn and Challenger, J. Chem. Soc. 1872-8 (1938).

C.A. 33, 1265[3] (1939).

Rx. 879



di-n-amyl disulfide — n-amyl mercaptan

II. Reduction

i. $-CHO \longrightarrow -CH_2SH$

Neuberg and Grauer, Z. physiol. Chem. 289, 253-6 (1952).

C.A. 48, 10840c (1954).

Rx. 880

$$CH_3\text{-}CHO \xrightarrow[\text{(plus } NH_4SH)]{\text{Zymomonas mobilis (Pseudomonas lindneri)}} CH_3\text{-}CH_2SH$$

acetaldehyde — ethanethiol (ethyl mercaptan)

Nord, Ber. 52B, 1207-11 (1919).

C.A. 14, 559 (1920).

Rx. 881

$$CH_3\text{-}CH_2\text{-}CH_2\text{-}CHO \xrightarrow{\text{yeast}} CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2SH$$

n-butyraldehyde — n-butyl mercaptan (7%)

Neuberg and Grauer, Z. physiol. Chem. 289, 253-6 (1952).

C.A. 48, 10840c (1954).

Rx. 882

$$CH_3\text{-}CH_2\text{-}CH_2\text{-}CHO \xrightarrow[\text{(plus } NH_4SH)]{\text{Zymomonas mobilis (Pseudomonas lindneri)}} CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2SH$$

n-butyraldehyde — n-butyl mercaptan

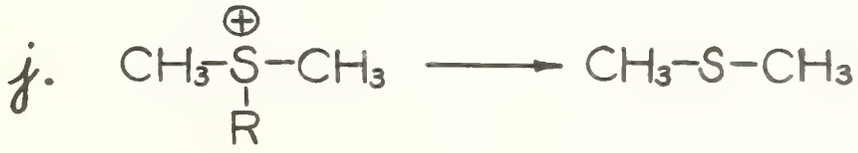
Nord, Ber. 52B, 1207-11 (1919).

C.A. 14, 559 (1920).

Rx. 883

isovaleraldehyde — isoamyl mercaptan

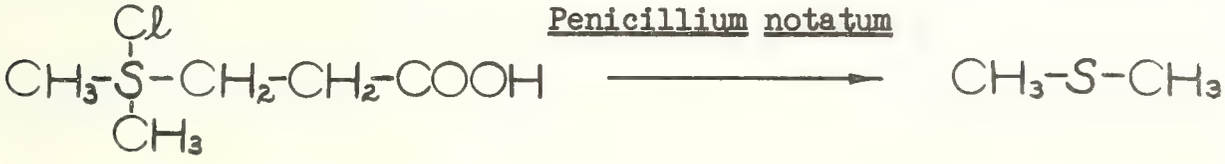
II. Reduction



Challenger and Liu, Rec. trav. chim. 69, 334-42 (1950).

C.A. 44, 6474a (1950).

Rx. 884

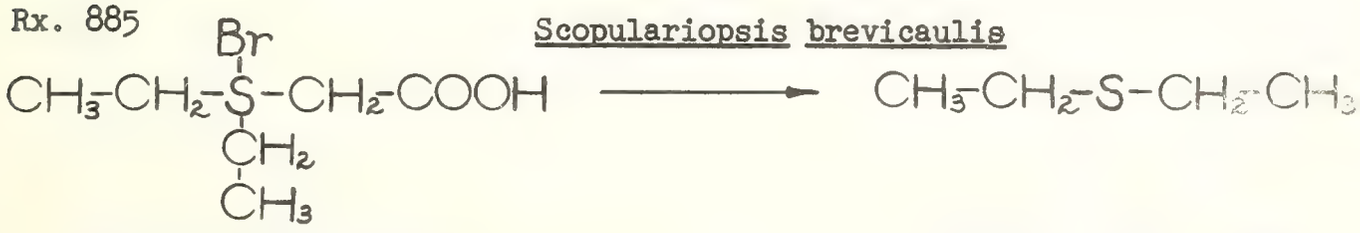


dimethyl-β-propiothetin chloride — dimethyl sulfide (36-44%)

Challenger and Liu, Rec. trav. chim. 69, 334-42 (1950).

C.A. 44, 6474a (1950).

Rx. 885

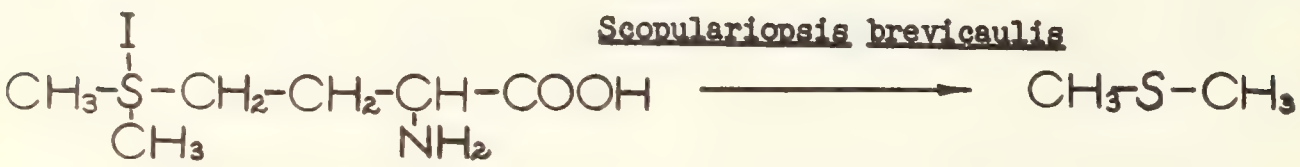


diethylthetin bromide — diethyl sulfide (24%)

Challenger and Charlton, J. Chem. Soc., 424-9 (1947).

C.A. 41, 5578d (1947).

Rx. 886

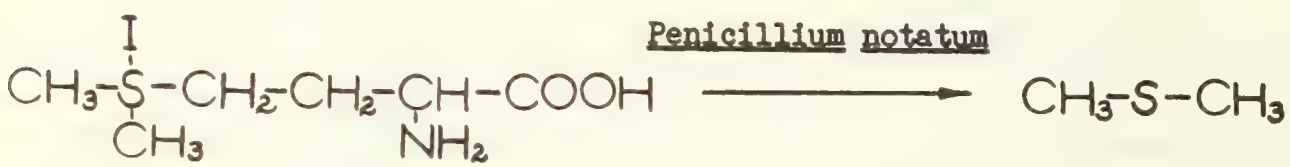


D,L-methionine methiodide — dimethyl sulfide

Challenger and Liu, Rec. trav. chim. 69, 334-42 (1950).

C.A. 44, 6474a (1950).

Rx. 887



D,L-methionine methiodide — dimethyl sulfide (14%)

II. Reduction

k. $\underset{\underset{OH}{|}}{CH_2}- \longrightarrow CH_3-$

Brasch, Biochem. Z. 22, 403-8 (1909).
C.A. 4, 475[4] (1910).

Rx. 888

$$\underset{\underset{OH}{|}}{CH_2}-COOH \xrightarrow{\underline{Clostridium\ lentoputrescens}\ (\underline{Bacillus\ putrificus})} CH_3-COOH$$

glycolic acid (glycocoll) — acetic acid

Brasch, Biochem. Z. 22, 403-8 (1909).
C.A. 4, 475[4] (1910).

Rx. 889

$$\underset{\underset{OH}{|}}{\overset{\overset{NH_2}{|}}{CH_2}}-CH-COOH \xrightarrow{\text{putrefactive bacteria}} CH_3-CH_2-COOH$$

serine — propionic acid

Desnuelle and Grand, Compt. rend. soc. biol. 138, 610-11 (1944).
C.A. 39, 4909[9] (1945).

Rx. 890

$$\underset{\underset{OH}{|}}{\overset{\overset{NH_2}{|}}{CH_2}}-CH-COOH \xrightarrow{\underline{Escherichia\ coli}\ (\underline{B.\ coli})} CH_3-\underset{\underset{O}{\|}}{C}-COOH$$

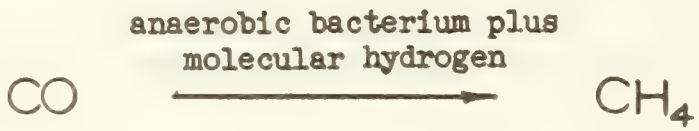
serine — pyruvic acid

II. Reduction

l. Reduction to methane

Stephenson and Stickland, Biochem. J. 27, 1517-27 (1933).
C.A. 28, 1370[5] (1934).

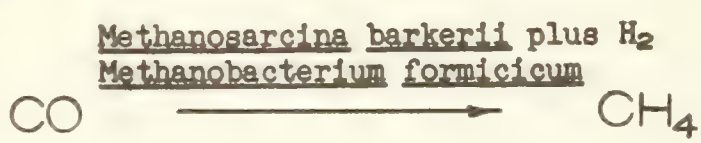
Rx. 891



carbon monoxide — methane

Kluyver and Schnellen, Arch. Biochem. 14, 57-70 (1947).
C.A. 42, 245f (1948).

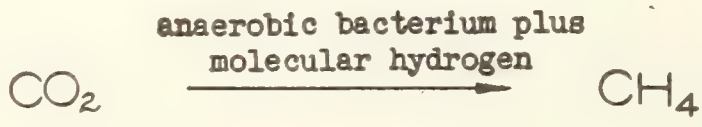
Rx. 892



carbon monoxide — methane (100%)

Stephenson and Stickland, Biochem. J. 27, 1517-27 (1933).
C.A. 28, 1370[5] (1934).

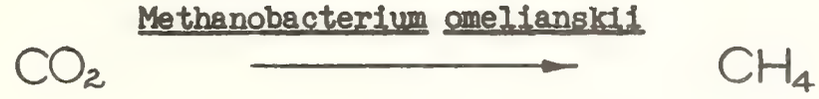
Rx. 893



carbon dioxide — methane

Kluyver and Schnellen, Arch. Biochem. 14, 57-70 (1947).
C.A. 42, 245f (1948).

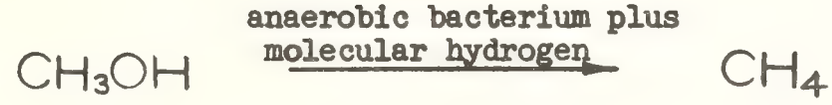
Rx. 894



carbon dioxide — methane

Stephenson and Stickland, Biochem. J. 27, 1517-27 (1933).
C.A. 28, 1370[5] (1934).

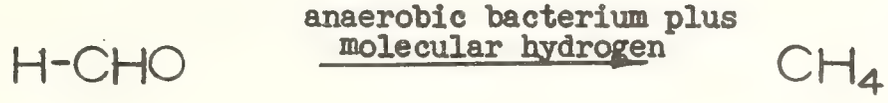
Rx. 895



methyl alcohol — methane

Stephenson and Stickland, Biochem. J. 27, 1517-27 (1933).
C.A. 28, 1370[5] (1934).

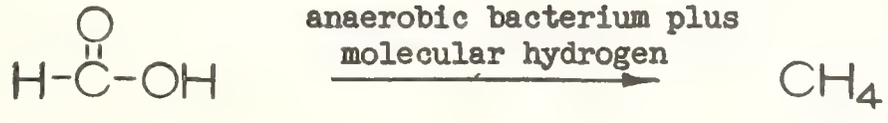
Rx. 896



formaldehyde (added as hexamethylenetetramine) — methane

Stephenson and Stickland, Biochem. J. 27, 1517-27 (1933).
C.A. 28, 1370[5] (1934).

Rx. 897

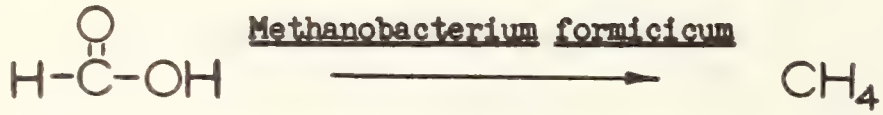


formic acid — methane

Kluyver and Schnellen, Arch. Biochem. 14, 57-70 (1947).

C.A. 42, 245f (1948).

Rx. 898



formic acid — methane

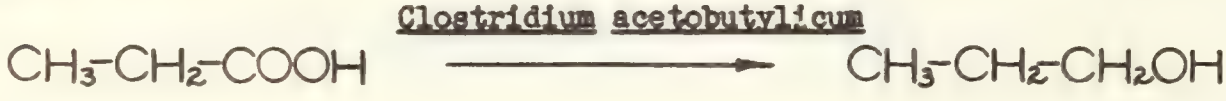
II. Reduction

m. Miscellaneous types

Blanchard and MacDonald, J. Biol. Chem. 110, 145-50 (1935).

C.A. 29, 4793[4] (1935).

Rx. 899

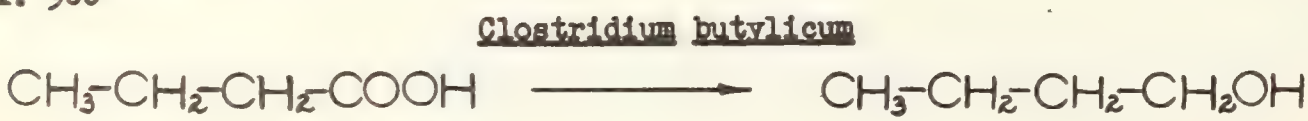


propionic acid — 1-propanol

Osburn et al., Iowa State Coll. J. Sci. 12, 275-84 (1938).

C.A. 32, 4715[9] (1938).

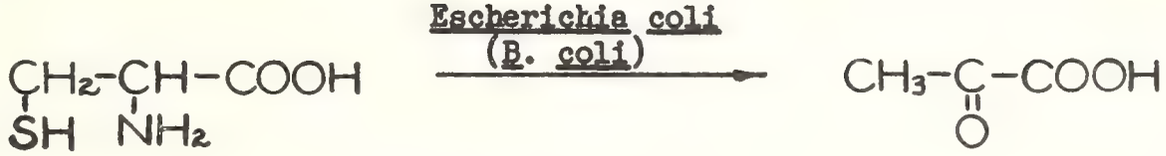
Rx. 900



n-butyric acid — 1-butanol

Desnuelle and Grand, Compt. rend. soc. biol. 138, 610-11 (1944).
C.A. 39, 4909[9] (1945).

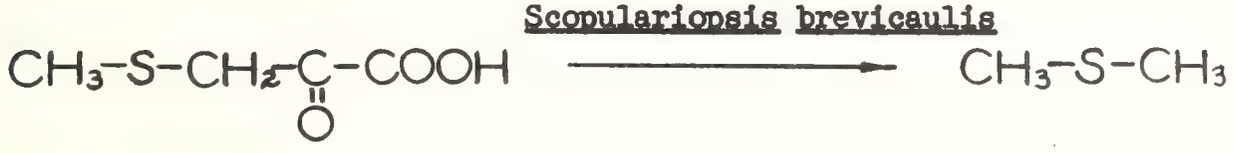
Rx. 901



cysteine — pyruvic acid

Challenger and Liu, Rec. trav. chim. 69, 334-42 (1950).
C.A. 44, 6474a (1950).

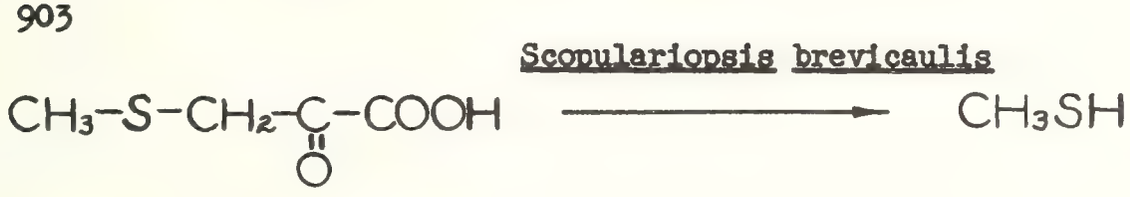
Rx. 902



β-methylmercaptopyruvic acid — dimethyl sulfide

Challenger and Liu, Rec. trav. chim. 69, 334-42 (1950).
C.A. 44, 6474a (1950).

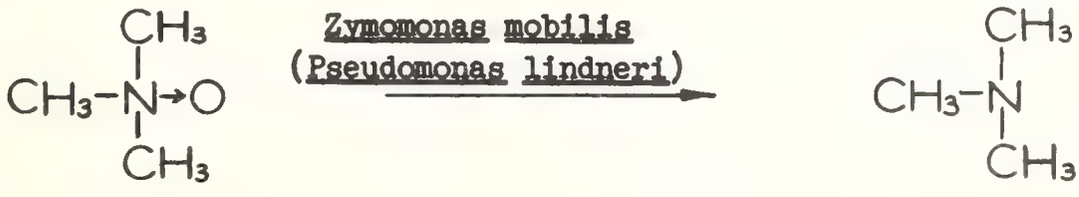
Rx. 903



β-methylmercaptopyruvic acid — methyl mercaptan

Neuberg, Bull. Research Council Israel 4 [1], 12-14 (1954).
C.A. 49, 4078b (1955).

Rx. 904

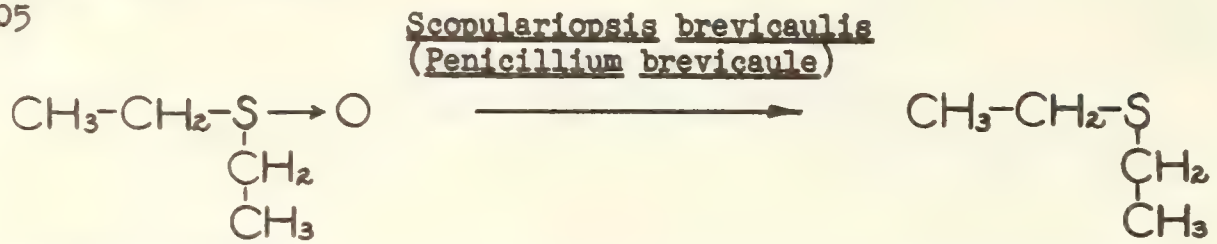


trimethylamine oxide — trimethylamine (66%)

Challenger and North, J. Chem. Soc., 68-71 (1934).

C.A. 28, 1983[9] (1934).

Rx. 905

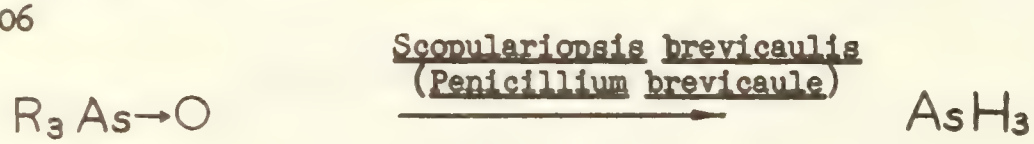


diethylsulfoxide — diethylsulfide

Challenger, Chemistry and Industry, 657-62 (1935).

C.A. 29, 6274[8] (1935).

Rx. 906

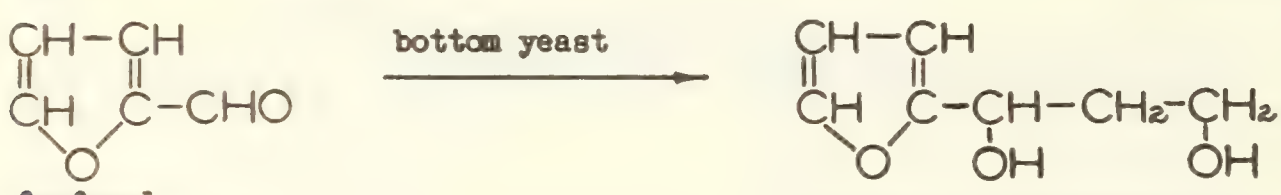


tertiary arsine oxides — arsine

Lintner and Liebig, Z. physiol. Chem. 88, 109-21 (1913).

C.A. 8, 1126[6] (1914).

Rx. 907

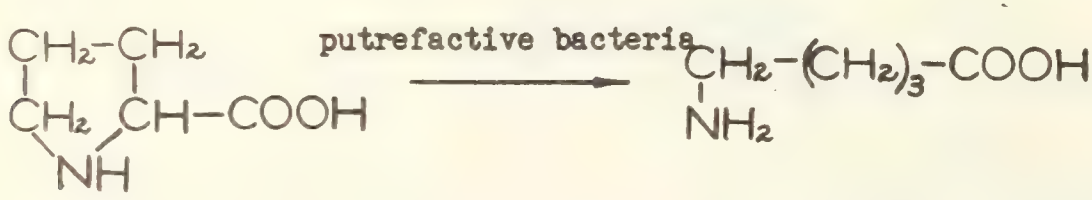


furfural — 1-furyl-1,3-propanediol

Ackermann, Z. Biol. 57, 104-11 (1911).

C.A. 6, 101[5] (1912).

Rx. 908

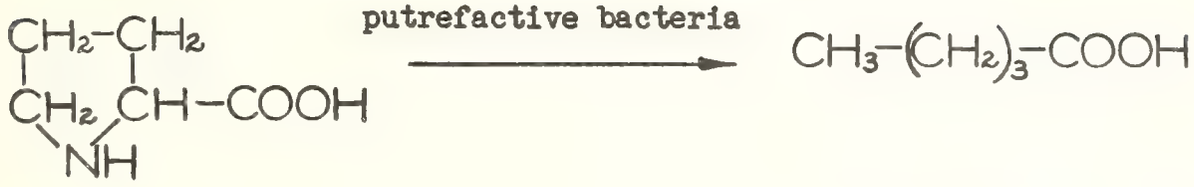


proline — δ-aminovaleric acid

Neuberg, Biochem. Z. 37, 490-500 (1911).

C.A. 6, 4947 (1912).

Rx. 909



d,l-proline

n-valeric acid

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

C.A. 29, 13839 (1935).

Rx. 910

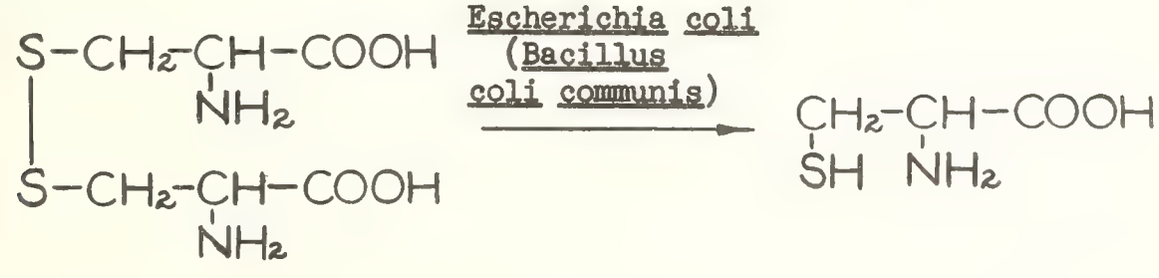
2,4-hexadienal
(sorbic aldehyde)

3-hexene-1-ol

Yaoi and Hosoya, Japan Med. World 6, 81-3 (1926).

C.A. 21, 5987 (1927).

Rx. 911



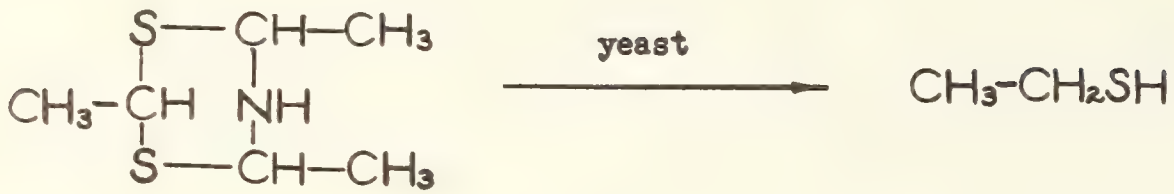
cystine

cysteine

Neuberg and Nord, Ber. 47B, 2264-71 (1914).

C.A. 8, 3299[3] (1914).

Rx. 912



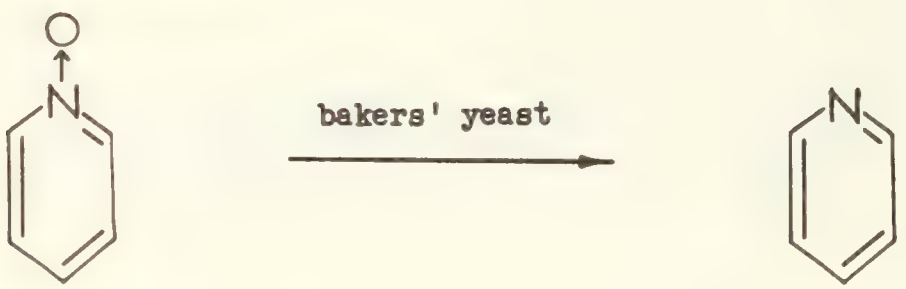
thialdine
(source of thioacetaldehyde)

ethanethiol
(ethyl mercaptan)

May, Enzymologia 18, 142-4 (1957).

C.A. 51, 16683f (1957).

Rx. 913



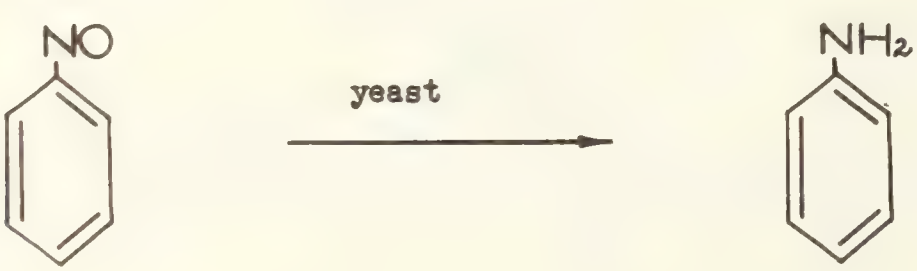
pyridine-N-oxide

pyridine (16%)

Neuberg and Welde, Biochem. Z. 67, 18-23 (1914).

C.A. 9, 58[6] (1915).

Rx. 914

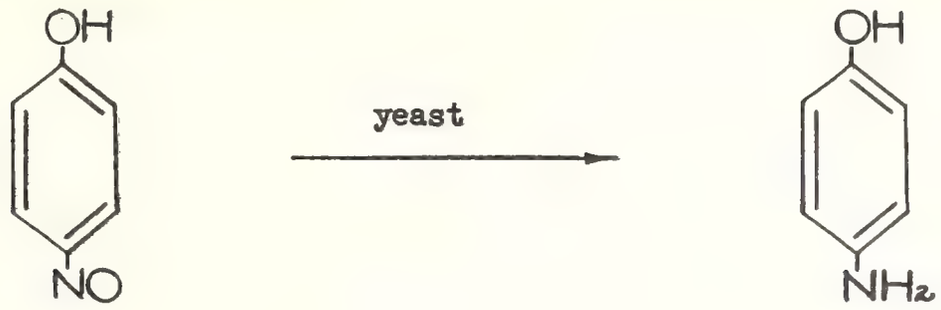


nitrosobenzene

aniline
(approx. 21%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).
C.A. 21, 2013[8] (1927).

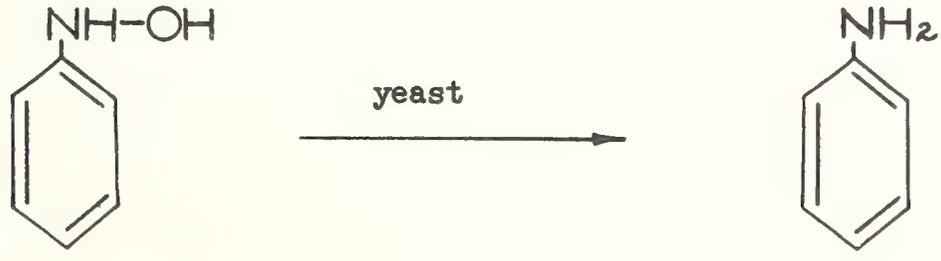
Rx. 915



p-nitrosophenol — p-aminophenol (40%)

Neuberg and Welde, Biochem. Z. 67, 18-23 (1914).
C.A. 9, 58[6] (1915).

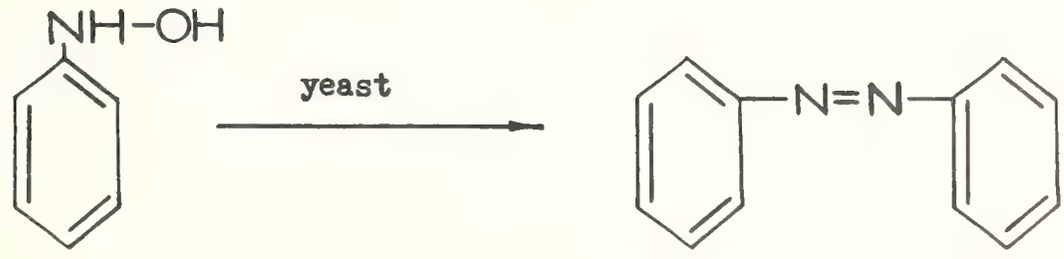
Rx. 916



phenylhydroxylamine — aniline (40%)

Neuberg and Welde, Biochem. Z. 67, 18-23 (1914).
C.A. 9, 58[6] (1915).

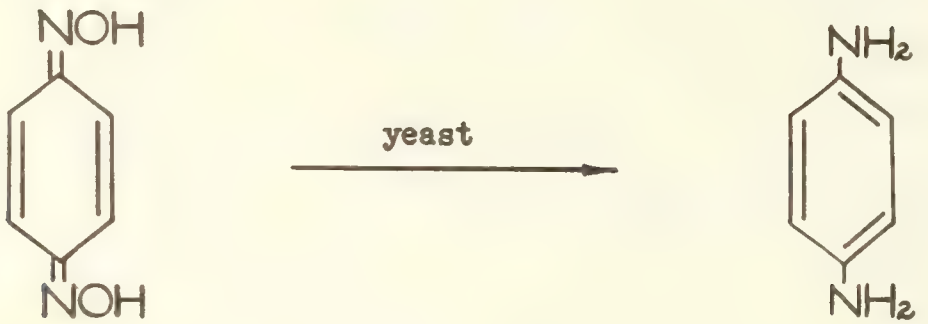
Rx. 917



phenylhydroxylamine — azobenzene (11%)

Lüers and Mengele, Biochem. Z. 179, 238-47 (1926).
C.A. 21, 2013[8] (1927).

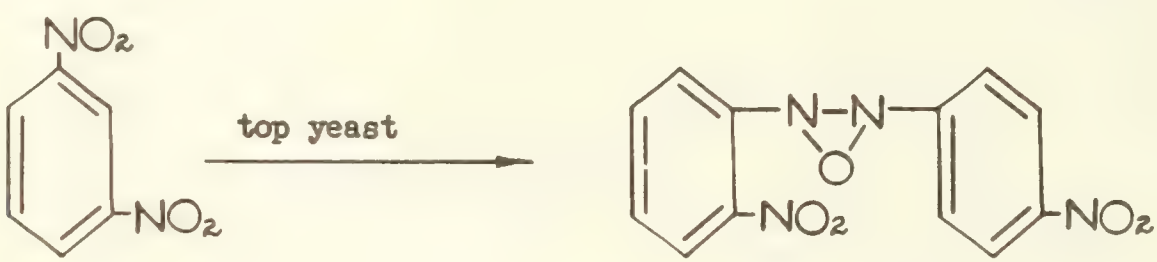
Rx. 918



benzoquinonedioxime — p-phenylenediamine (62%)

Neuberg and Reinfurth, Biochem. Z. 138, 561-8 (1923).
C.A. 18, 102[9] (1924).

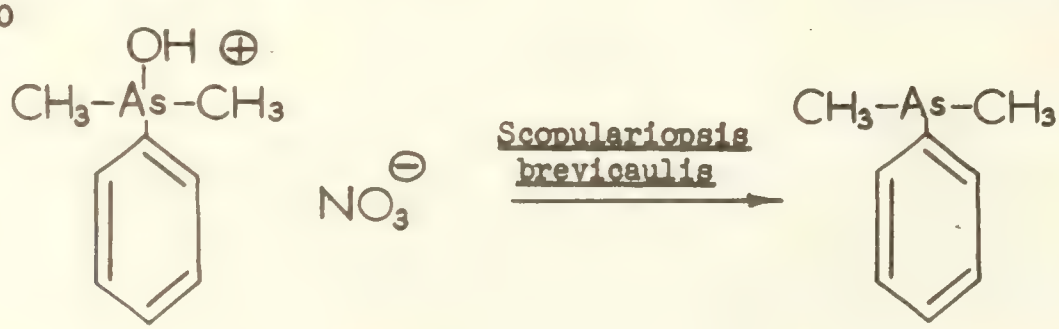
Rx. 919



m-dinitrobenzene — m-dinitroazoxybenzene

Bird et al., Biochem. J. 43, 78-83 (1948).
C.A. 43, 2670g (1949).

Rx. 920

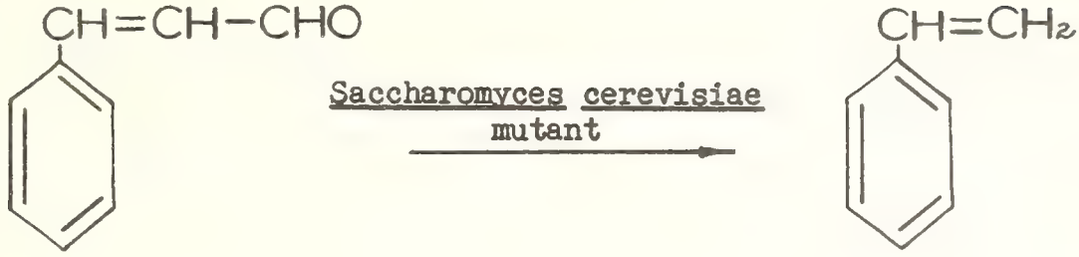


phenyldimethylhydroxyarsonium nitrate — phenyldimethylarsine

Chen and Peppler, J. Biol. Chem. 221, 101-6 (1956).

C.A. 50, 14049i (1956).

Rx. 921

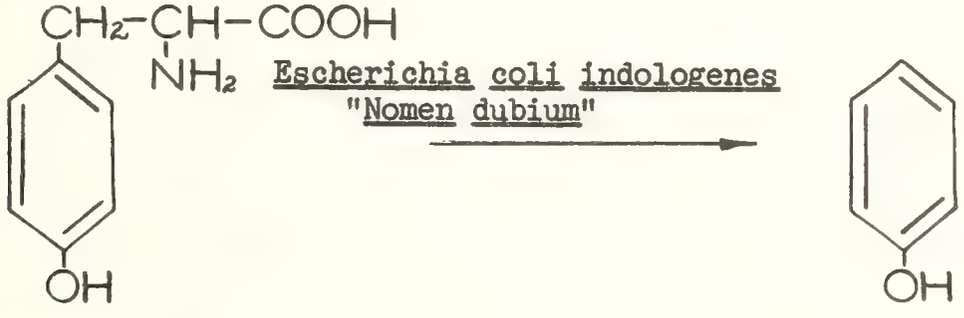


cinnamic aldehyde — styrene

Ichihara et al., J. Biochem. (Japan) 42, 529-32 (1955).

C.A. 50, 1120f (1956).

Rx. 922

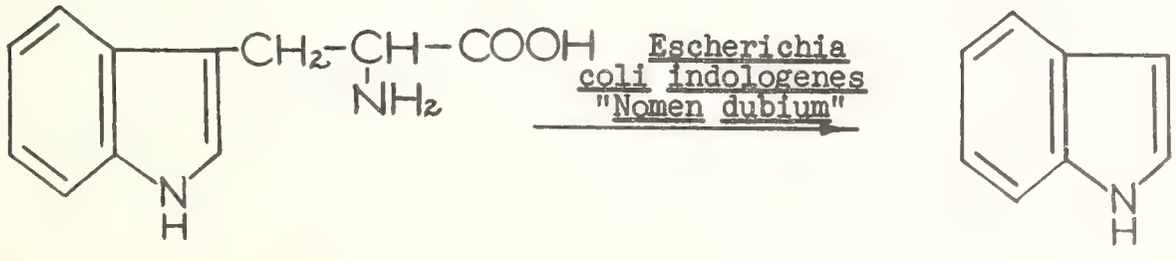


tyrosine — phenol

Ichihara et al., J. Biochem. (Japan) 42, 529-32 (1955).

C.A. 50, 1120f (1956).

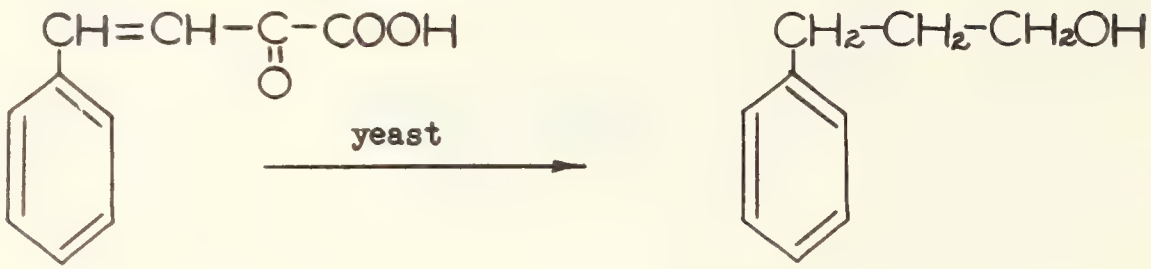
Rx. 923



tryptophane — indole

Fischer and Wiedemann, Ann. 513, 260-80 (1934).
C.A. 29, 13839 (1935).

Rx. 924

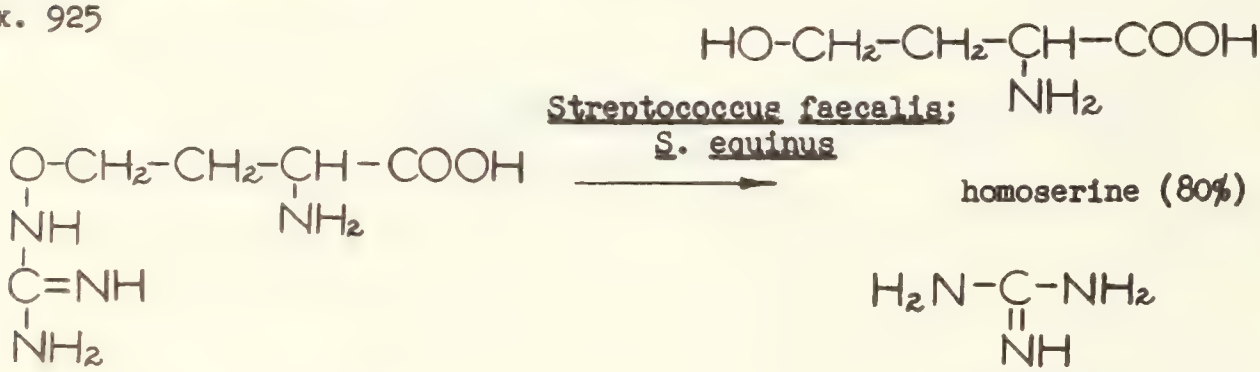


benzalpyruvic acid — 3-phenyl-1-propanol (75%)

Kihara et al., J. Biol. Chem. 217, 497-503 (1955).

C.A. 50, 4301d (1956).

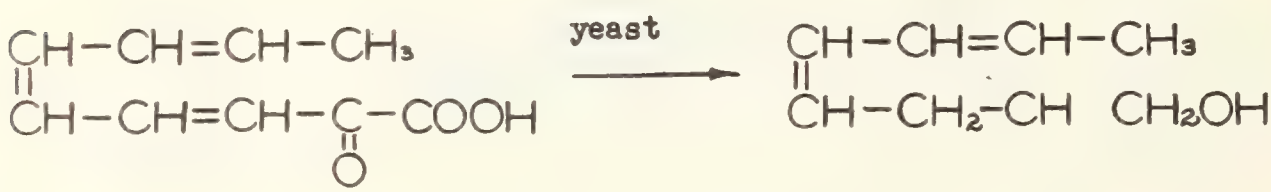
Rx. 925



canavanine — guanidine

Fischer and Wiedemann, Ann. 522, 1-16 (1936).
C.A. 30, 37806 (1936).

Rx. 926

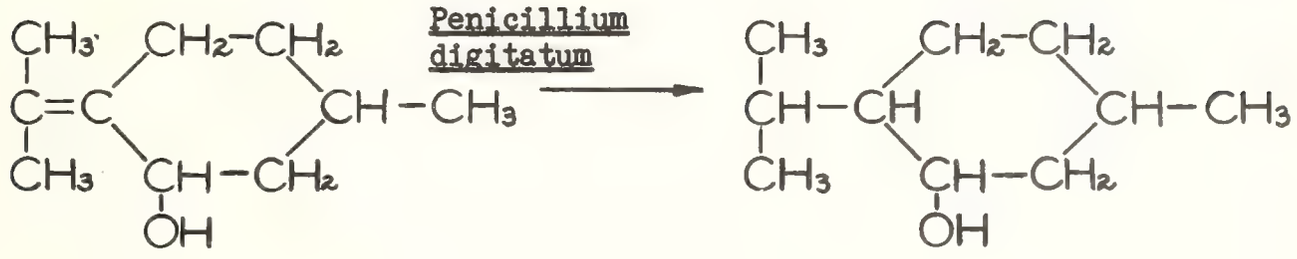


2-keto-3,5,7-nonatrienoic acid — 4,6-octadiene-1-ol

Babička et al., Czech. 84,320 (May 1, 1955).

C.A. 50, 9686b (1956).

Rx. 927

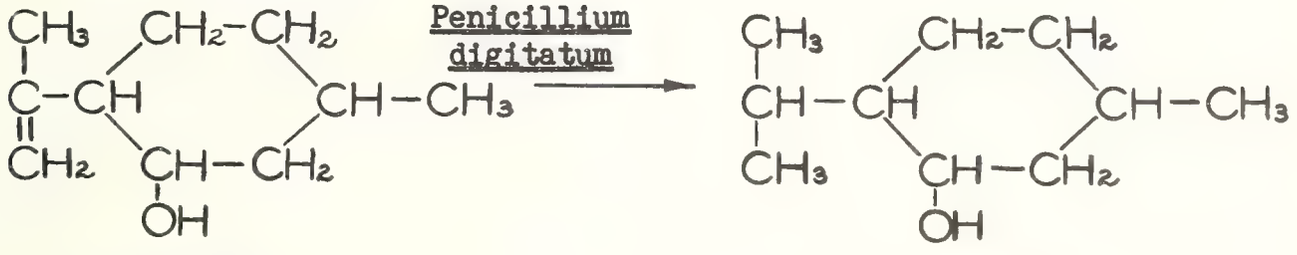


pulegol menthol

Babička et al., Czech. 84,320 (May 1, 1955).

C.A. 50, 9686b (1956).

Rx. 928



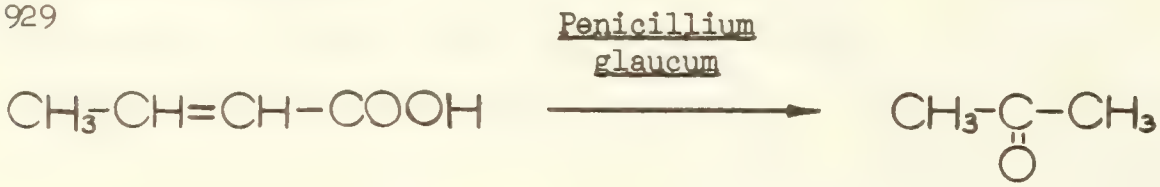
isopulegol menthol

III. Decarboxylation

a. $-CH_2-COOH \longrightarrow -CH_3$

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).
C.A. 37, 155[1] (1943).

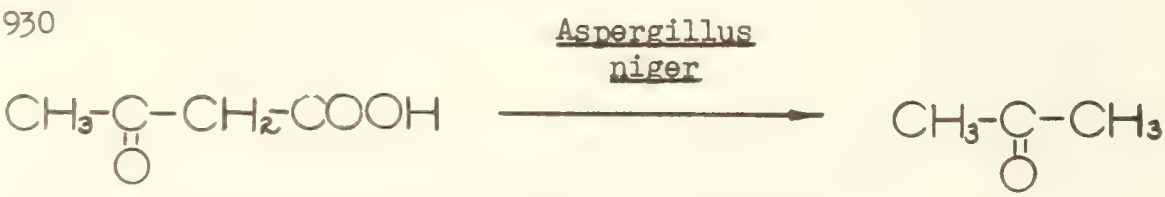
Rx. 929



crotonic acid — acetone (2-propanone)

Coppock et al., J. Chem. Soc., 1422-7 (1928).
C.A. 22, 3425[5] (1928).

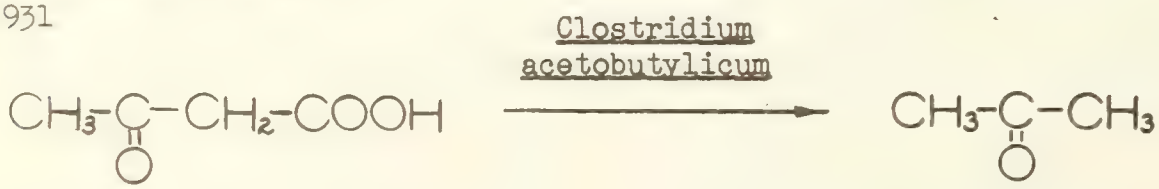
Rx. 930



acetoacetic acid — acetone (5-60%)

Peterson and Johnson, J. Bacteriol. 25, 69 (1933).
C.A. 27, 1981[1] (1933).

Rx. 931

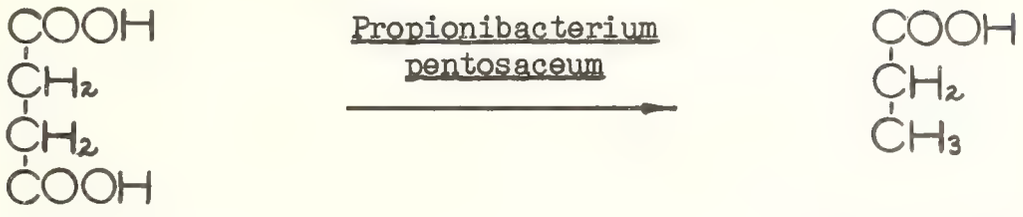


acetoacetic acid — acetone

Delwiche, J. Bacteriol. 59, 439-42 (1950).

C.A. 44, 4959d (1950).

Rx. 932

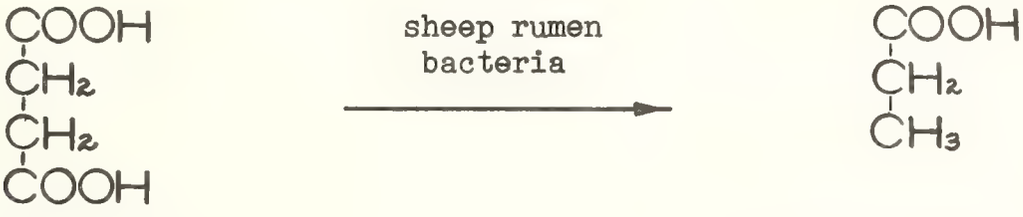


succinic acid → propionic acid

Sijpesteijn and Elsden, Biochem. J. 52, 41-5 (1952).

C.A. 47, 1228b (1953).

Rx. 933

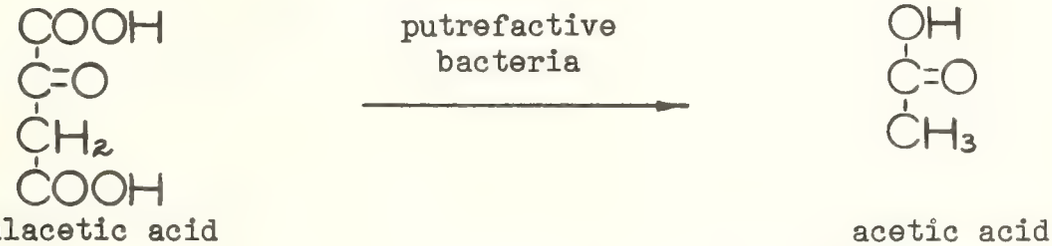


succinic acid → propionic acid (100%)

Neuberg, Biochem. Z. 67, 90-101 (1914).

C.A. 9, 472[8] (1915).

Rx. 934

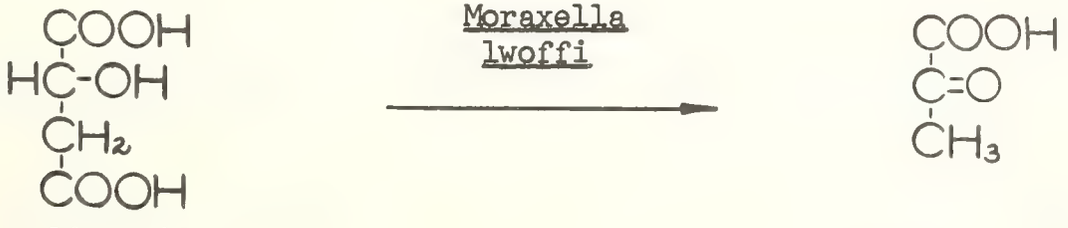


oxalacetic acid → acetic acid

Lwoff and Ionesco, Compt. rend. 224, 1664-6 (1947).

C.A. 42, 3019b (1948).

Rx. 935

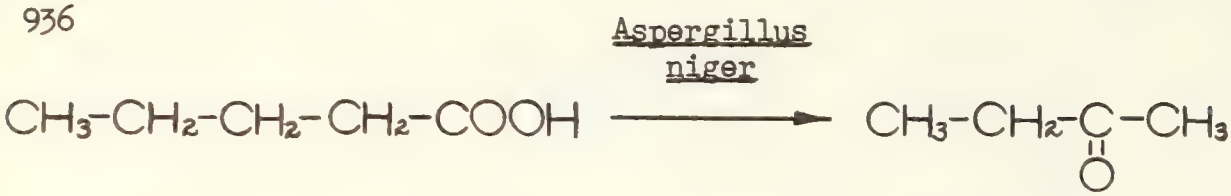


malic acid → pyruvic acid

Coppock et al., J. Chem. Soc., 1422-7 (1928).

C.A. 22, 3425[5] (1928).

Rx. 936

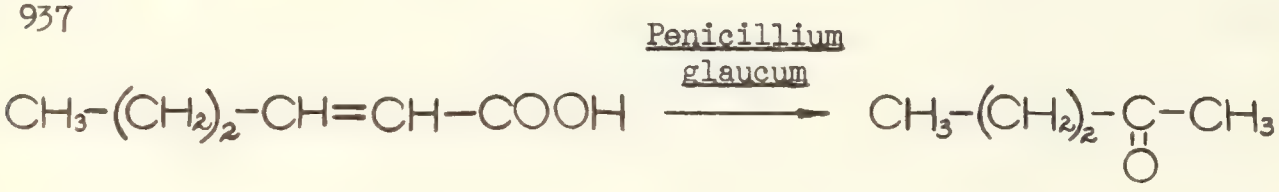


n-valeric acid (Ca salt) — 2-butanone (50%) (methylethylketone)

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).

C.A. 37, 155[1] (1943).

Rx. 937

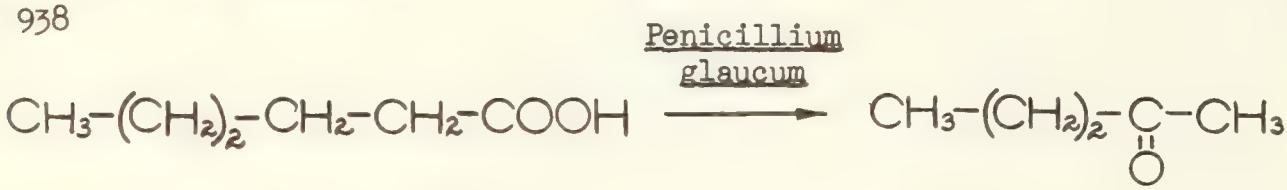


2-hexenoic acid — 2-pentanone (n-propylmethylketone)

Stärkle, Biochem. Z. 151, 371-415 (1924).

C.A. 19, 2244[8] (1925).

Rx. 938

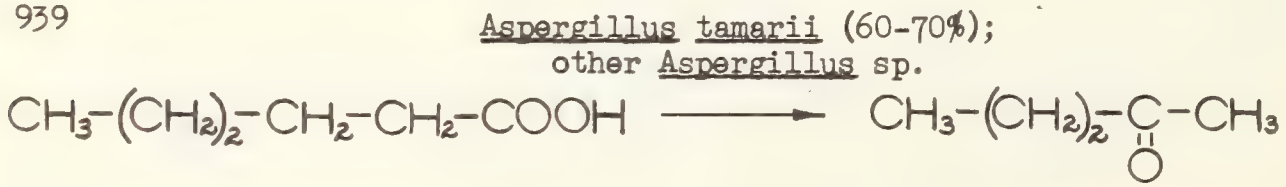


n-caproic acid (ammonium salt) — 2-pentanone

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 939

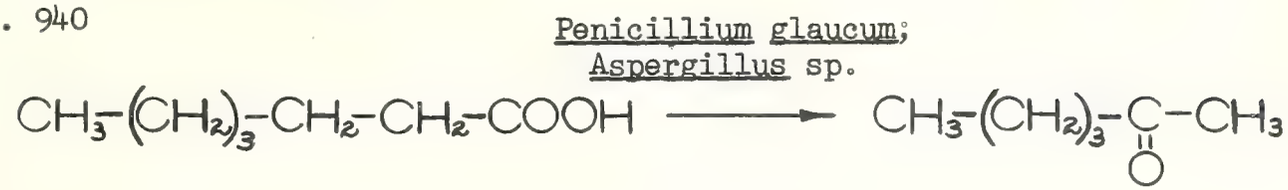


n-caproic acid — 2-pentanone

Stärkle, Biochem. Z. 151, 371-415 (1924).

C.A. 19, 2244[8] (1925).

Rx. 940

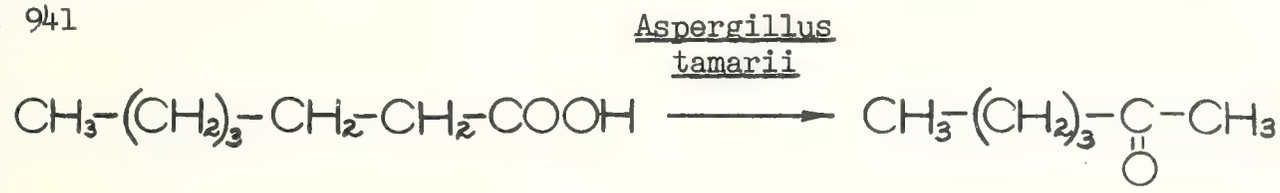


enanthic acid (from fat) — 2-hexanone (n-butylmethylketone)

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 941

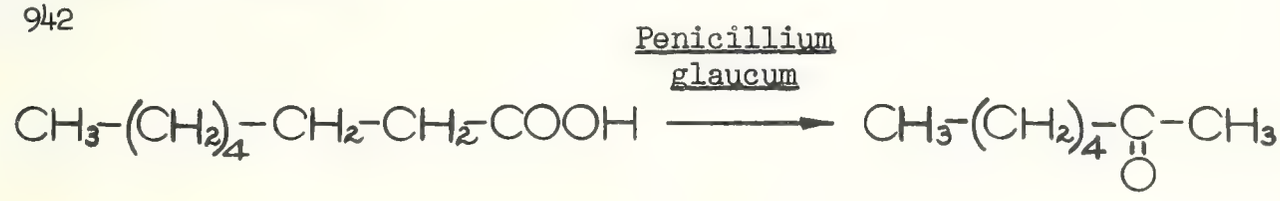


enanthic acid — 2-hexanone

Stärkle, Biochem. Z. 151, 371-415 (1924).

C.A. 19, 2244[8] (1925).

Rx. 942

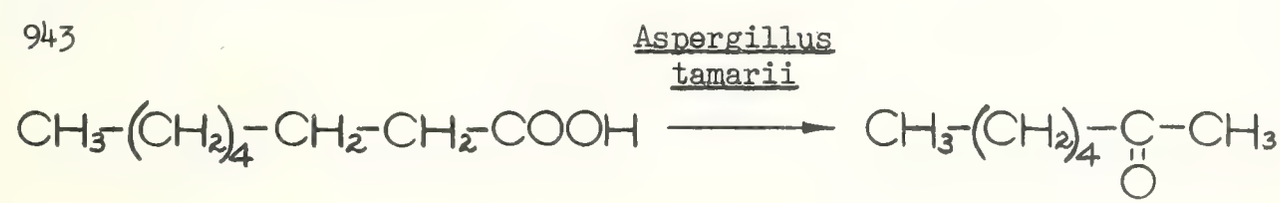


caprylic acid (NH_4 salt) — 2-heptanone (n-amylmethylketone)

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 943

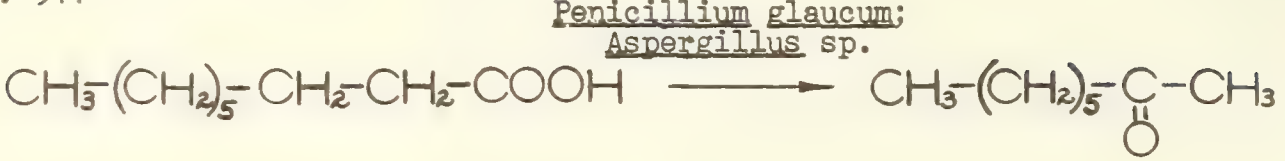


caprylic acid — 2-heptanone

Stärkle, Biochem. Z. 151, 371-415 (1924).

C.A. 19, 2244[8] (1925).

Rx. 944

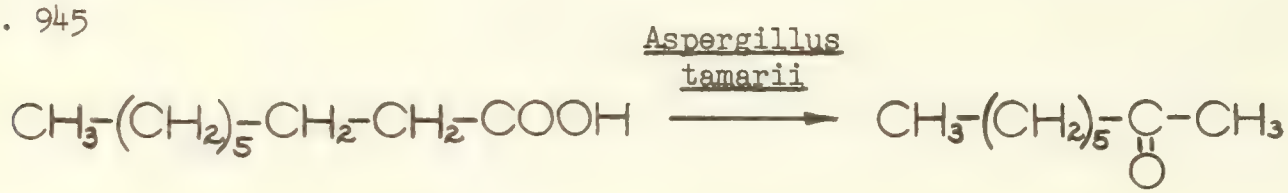


pelargonic acid — 2-octanone (n-hexylmethylketone)

Karabinos and Ferlin, Euclides (Madrid) 16, 171-5 (1956).

C.A. 51, 10654g (1957).

Rx. 945

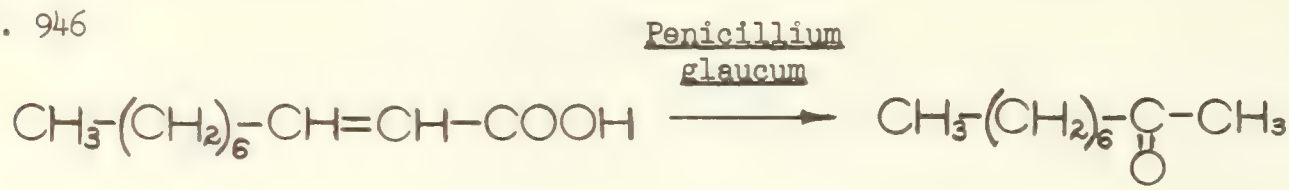


pelargonic acid — 2-octanone

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).

C.A. 37, 155[1] (1943).

Rx. 946

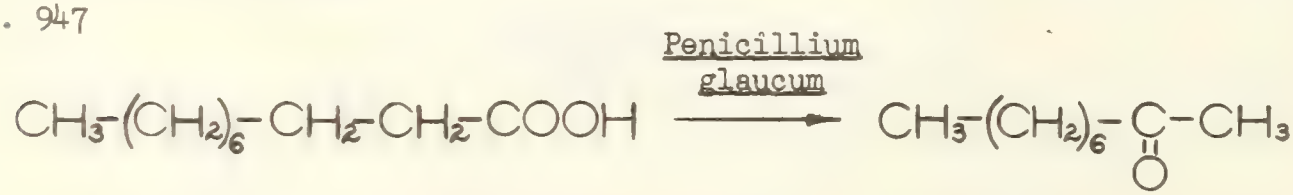


2-decenoic acid — 2-nonanone (n-heptylmethylketone)

Stärkle, Biochem. Z. 151, 371-415 (1924).

C.A. 19, 2244[8] (1925).

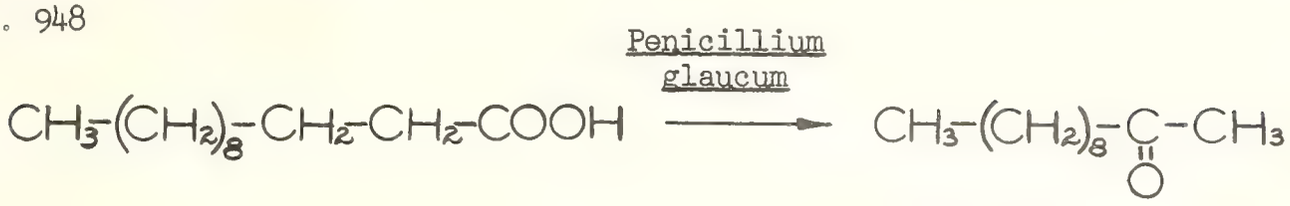
Rx. 947



capric acid (ammonium salt) — 2-nonanone

Stärkle, Biochem. Z. 151, 371-415 (1924).
C.A. 19, 2244[8] (1925).

Rx. 948

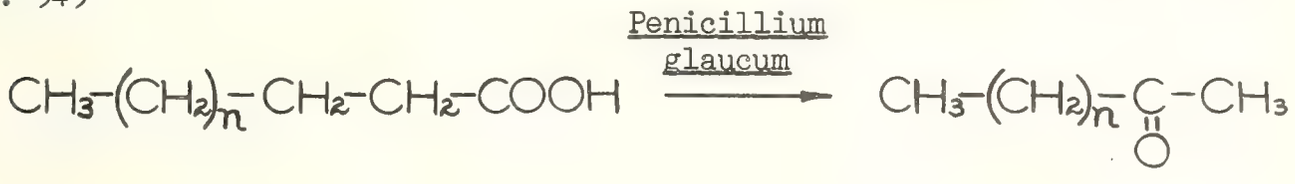


lauric acid (ammonium salt)

2-undecanone
(n-nonylmethylketone)

Acklin, Biochem. Z. 204, 253-74 (1929). See Karrer and Haab, Helv. Chim. Acta 31, 795-8 (1948).
C.A. 23, 1927[3] (1929).

Rx. 949

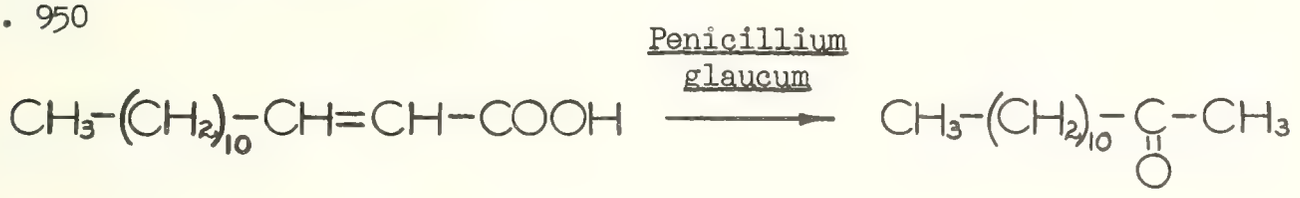


monocarboxylic fatty acids
(n = 2-10)

2-alkanones

Thaler and Eisenlohr, Biochem. Z. 308, 88-102 (1941).
C.A. 37, 155[1] (1943).

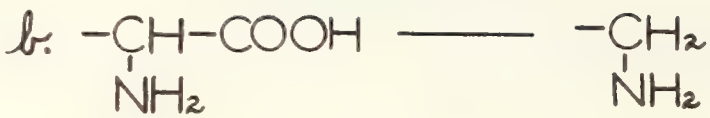
Rx. 950



2-tetradecenoic acid

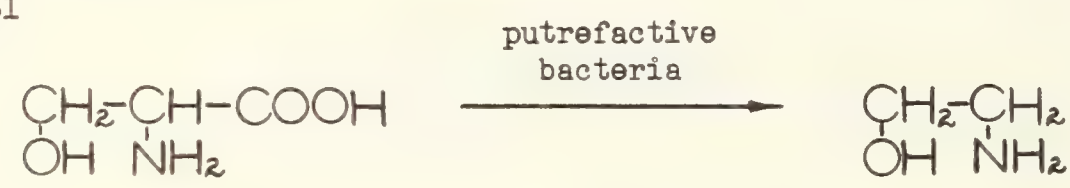
2-tridecanone
(n-undecylmethylketone)

III. Decarboxylation



Nord, Biochem. Z. 95, 281-5 (1919).
C.A. 14, 932[2] (1920).

Rx. 951

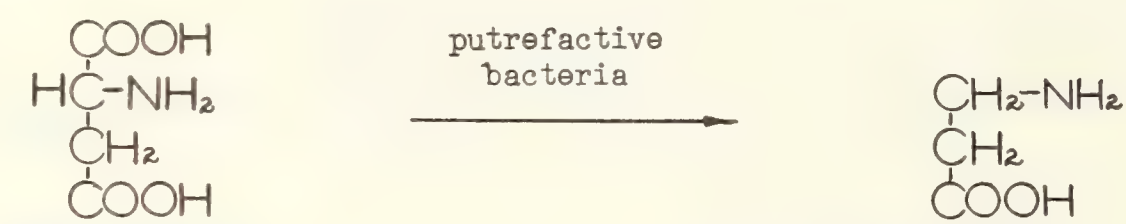


serine

2-aminoethanol
(approx. 6%)

Ackermann, Z. Biol. 56, 87-90 (1911).
C.A. 6, 101[4] (1912).

Rx. 952

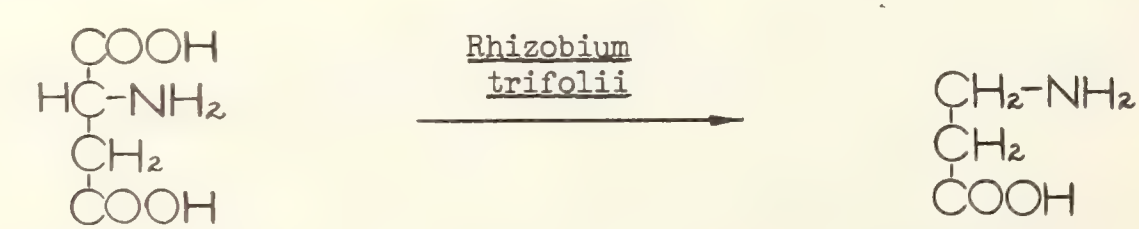


aspartic acid

β-alanine

Billen and Lichstein, J. Bacteriol. 57, 267-8 (1949).
C.A. 43, 4336f (1949).

Rx. 953

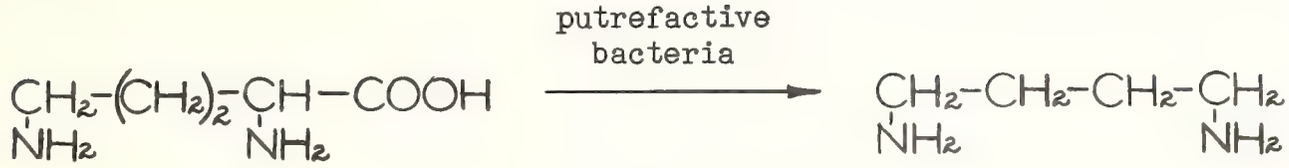


aspartic acid

β-alanine

Ellinger, Ber. 31B, 3183-6 (1898).
Brit. C.A. 76 [i], 186 (1899).

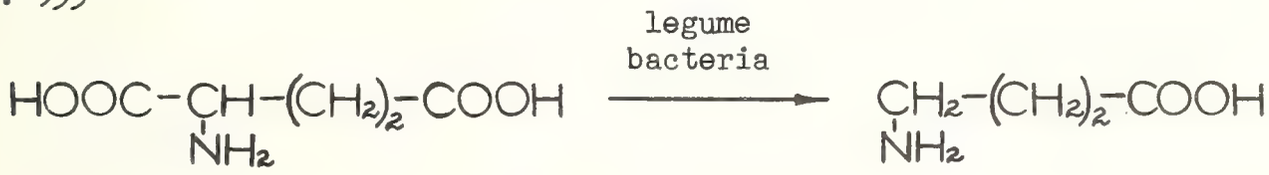
Rx. 954



ornithine — putrescine (1,4-diaminobutane)

Virtanen et al., Nature 142, 674 (1938).
C.A. 33, 2165[6] (1939).

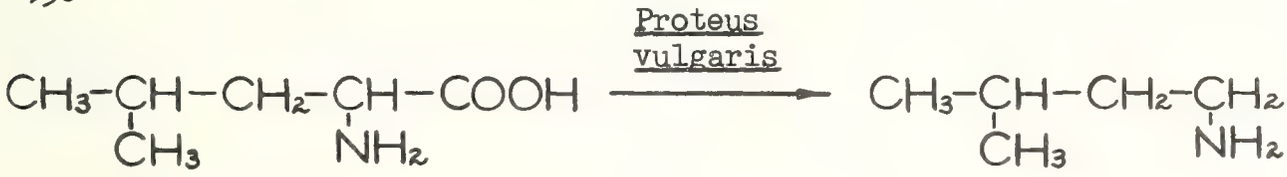
Rx. 955



L-glutamic acid — γ-aminobutyric acid

Arai, Biochem. Z. 122, 251-7 (1921).
C.A. 16, 945[5] (1922).

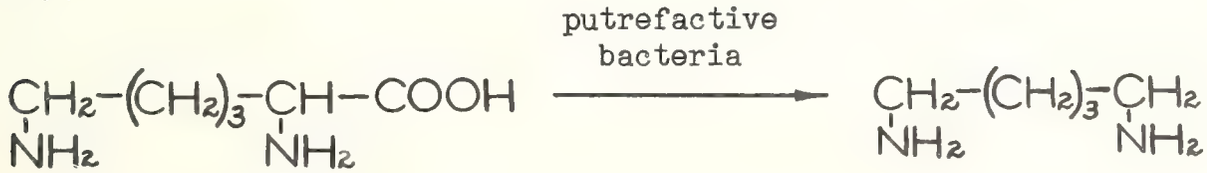
Rx. 956



l-leucine — 3-methyl-1-aminobutane (approx.5%) (isoamylamine)

Ellinger, Z. physiol. Chem. 29, 334-48 (1900). See Ber. 32B, 3542-6 (1899).
Brit. C.A. 78 [i], 143 (1900).

Rx. 957

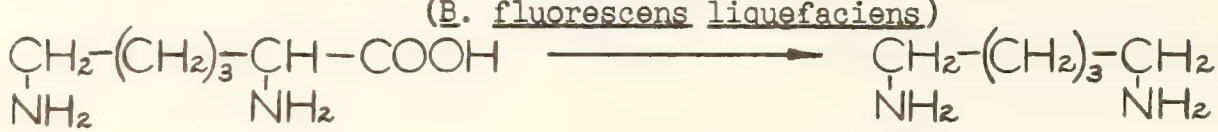


lysine — cadaverine (1,5-diaminopentane)

Virtanen and Laine, Suomen Kemistilehti 9B, 17-18 (1936).

C.A. 31, 2631[1] (1937).

Rx. 958

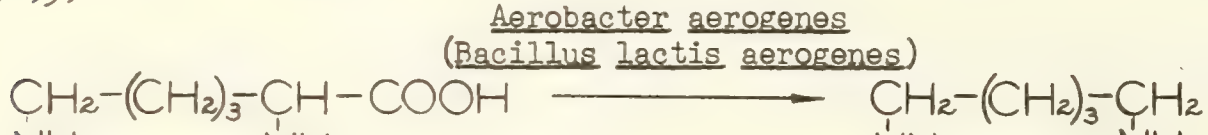


lysine — cadaverine

Hirai, J. Biochem. (Japan) 29, 435-8 (1939).

C.A. 33, 8674[7] (1939).

Rx. 959

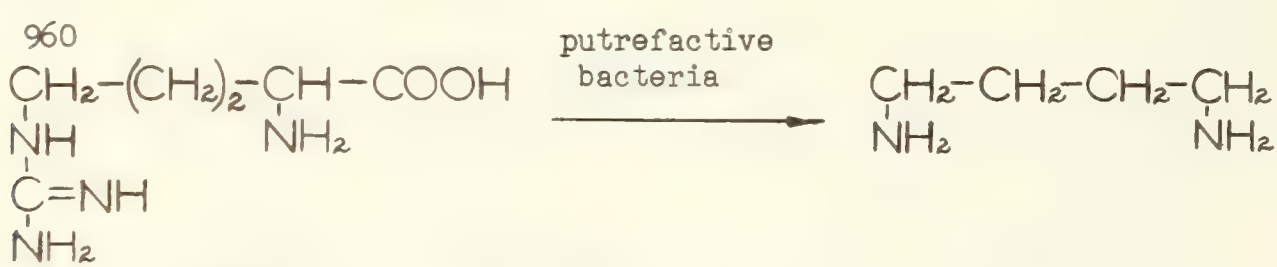


lysine — cadaverine

Ackermann, Z. physiol. Chem. 60, 482-501 (1909).

C.A. 4, 474[8] (1910).

Rx. 960

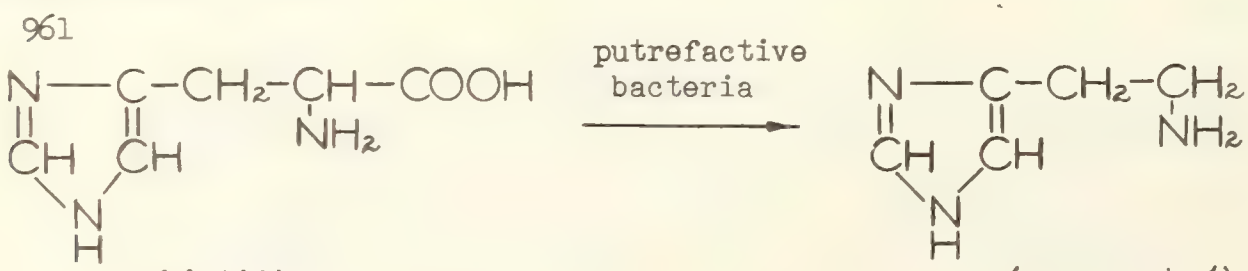


arginine — putrescine

Ackermann, Z. physiol. Chem. 65, 504-10 (1910).

C.A. 5, 1460[7] (1911).

Rx. 961

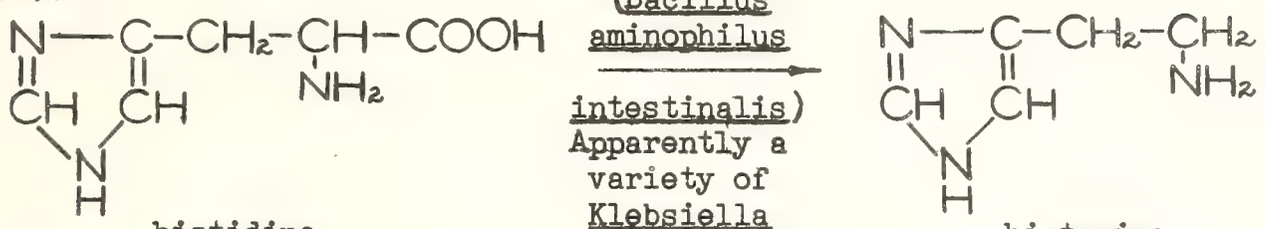


histidine — histamine (approx. 40%)

Berthelot and Bertrand, Compt. rend. 154, 1643-5 (1912).

C.A. 6, 3443[5] (1912).

Rx. 962

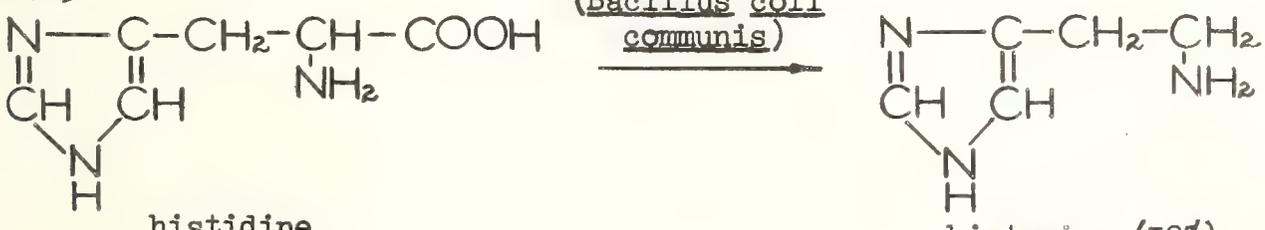


histidine → histamine

Koessler and Hanke, J. Biol. Chem. 39, 539-84 (1919).

C.A. 13, 3206[3] (1919).

Rx. 963

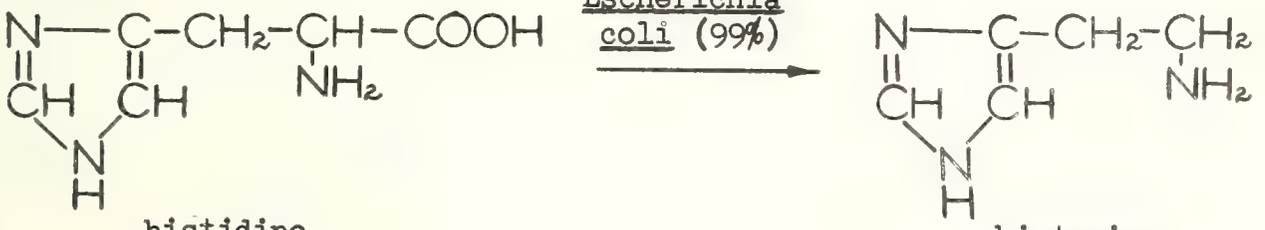


histidine → histamine (50%)

Koessler et al., J. Infectious Diseases 43, 363-77 (1928).

C.A. 23, 4962[9] (1929).

Rx. 964

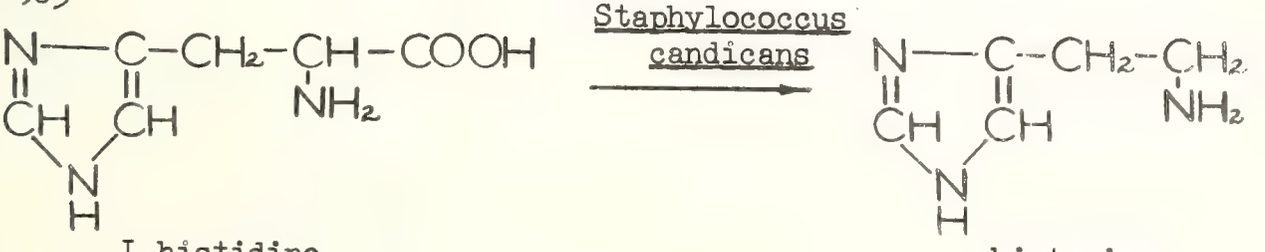


histidine → histamine

Gladkova et al., Mikrobiologiya 22, 141-4 (1953).

C.A. 47, 12523b (1953).

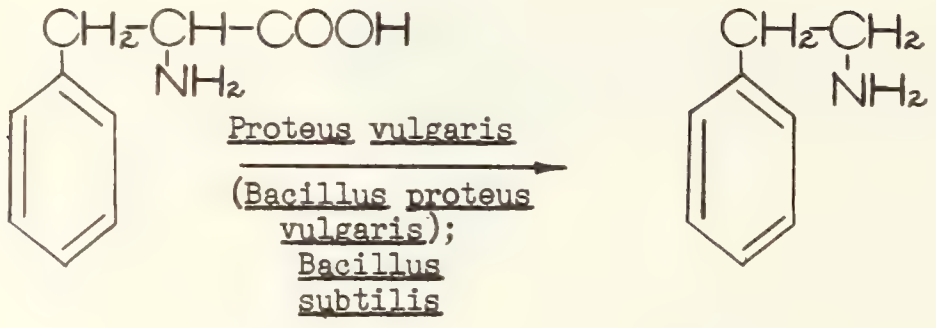
Rx. 965



L-histidine → histamine

Amatsu and Tsudji, Acta Schol. Med. Univ. Kioto 2, 447-57 (1918).
C.A. 14, 1695[4] (1920).

Rx. 966

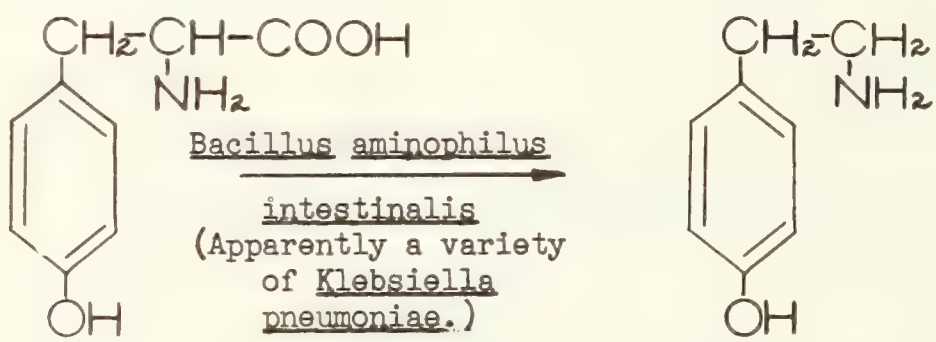


d,l-phenylalanine

β-phenylethylamine

Berthelot and Bertrand, Compt. rend. 154, 1826-8 (1912).
C.A. 6, 3443[7] (1912).

Rx. 967

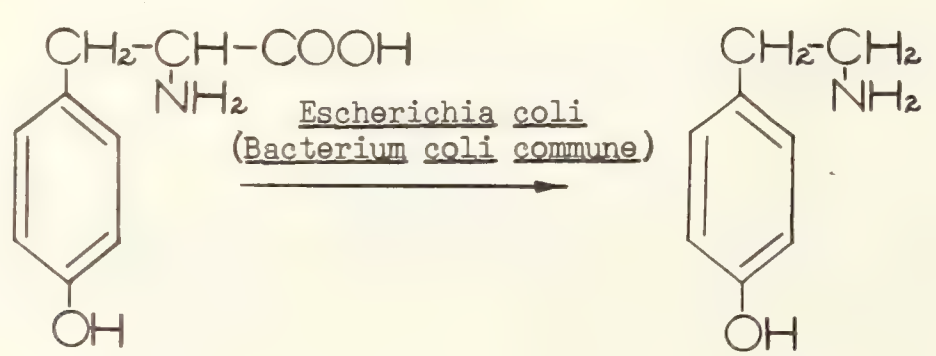


tyrosine

p-hydroxyphenylethylamine (tyramine)

Sasaki, Biochem. Z. 59, 429-35 (1914).
C.A. 8, 1806[2] (1914).

Rx. 968

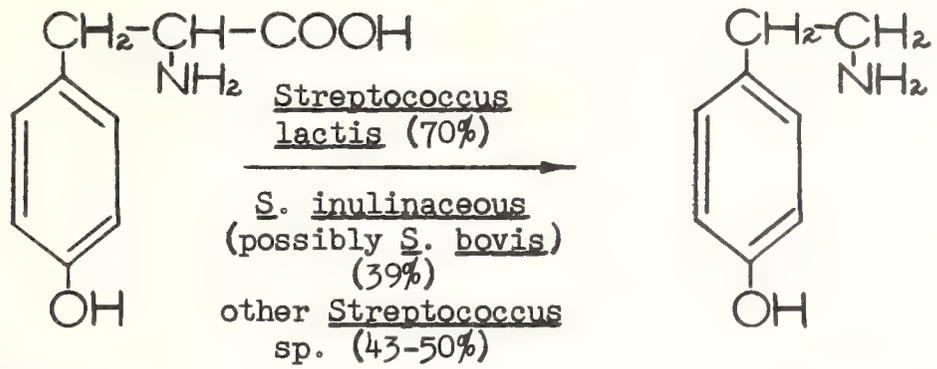


tyrosine

p-hydroxyphenylethylamine (79%)

Koessler et al., J. Infectious Diseases 43, 363-77 (1928).
C.A. 23, 4962[9] (1929).

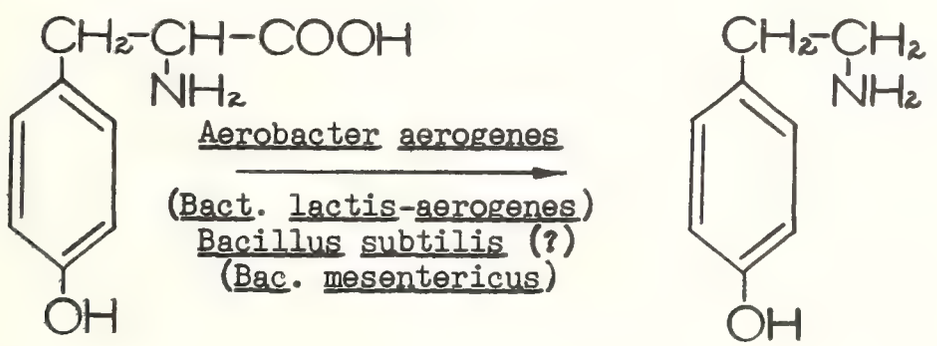
Rx. 969



tyrosine — tyramine

Grimmer and Wauschkuhn, Milchw. Forsch. 20, 110-30 (1939).
C.A. 34, 2414[5] (1940).

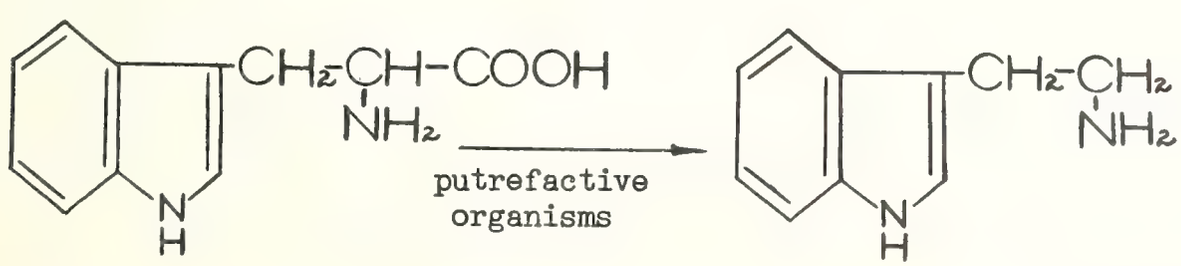
Rx. 970



tyrosine — tyramine

Ewins and Laidlaw, Proc. Chem. Soc. (London) 26, 343 (1911).
C.A. 5, 3570[5] (1911).

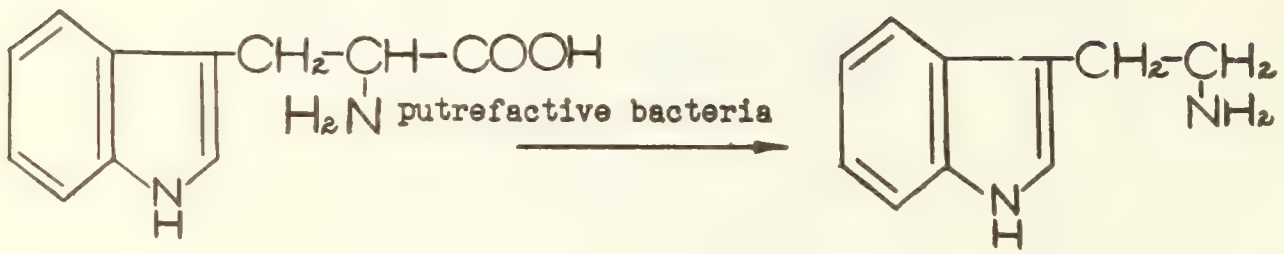
Rx. 971



tryptophane — tryptamine (3-(β-aminoethyl)-indole)

Laidlaw, Biochem. J. 6, 141-50 (1912).
C.A. 6, 1929[9] (1912).

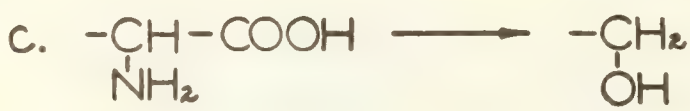
Rx. 972



tryptophane

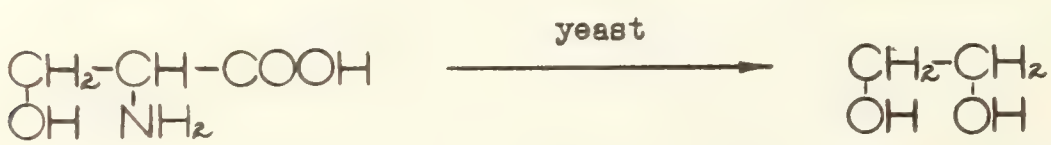
tryptamine
(3-(β-aminoethyl)-indole)

III. Decarboxylation



Ehrlich, Biochem. Z. 8, 438-66 (1908).
C.A. 2, 2568[2] (1908).

Rx. 973



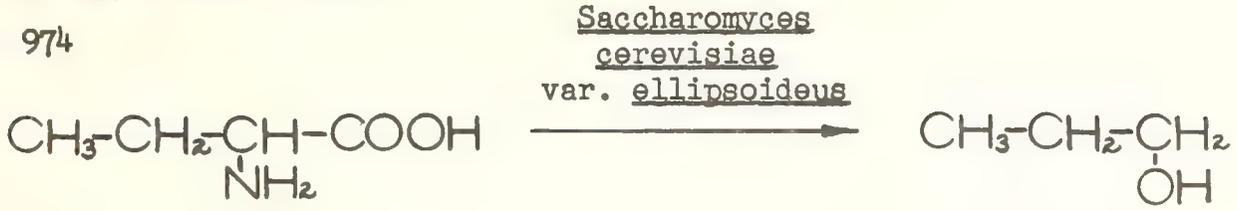
d,l-serine

1,2-ethanediol
(ethylene glycol)

Kepner et al., Arch. Biochem. Biophys. 51, 88-93 (1954).

C.A. 48, 10991b (1954).

Rx. 974

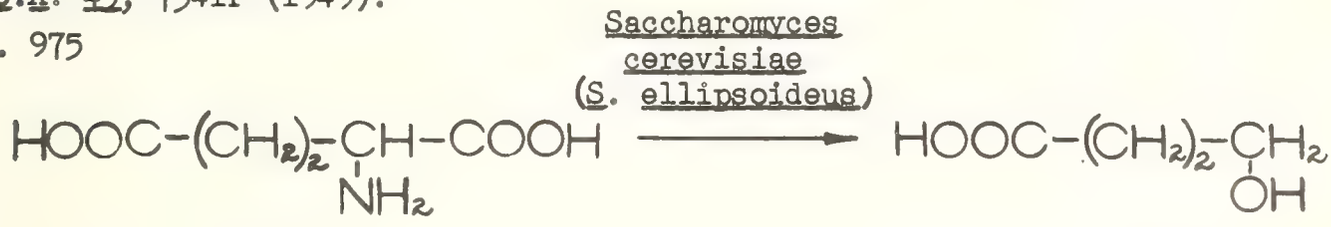


α-amino-n-butyric acid — 1-propanol (approx. 3%)

Antoniani and Cioffi, Ann. chim. applicata 38, 429-33 (1948).

C.A. 43, 7541f (1949).

Rx. 975

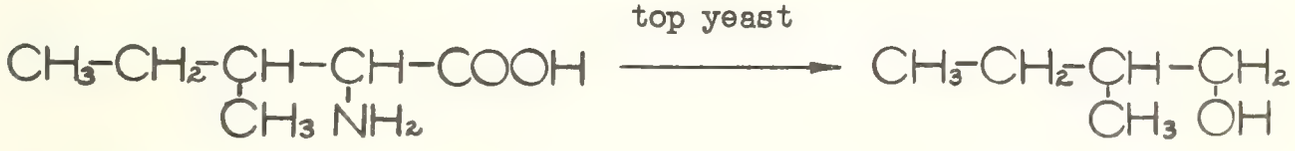


glutamic acid — γ-hydroxybutyric acid

Ehrlich, Ber. 40B, 1027-47 (1907).

C.A. 1, 1539[6] (1907).

Rx. 976

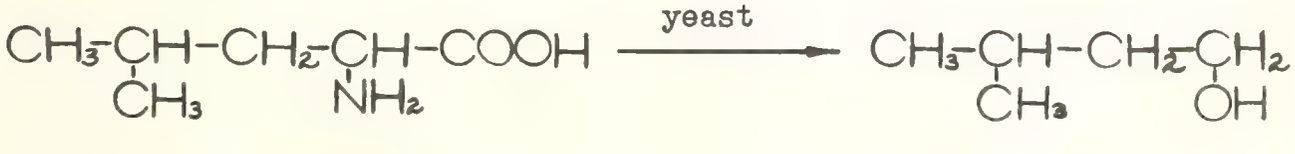


isoleucine — 2-methyl-1-butanol

Ehrlich, Biochem. Z. through Z. ges. Brauw. 38, (1907).

C.A. 1, 2928[1] (1907).

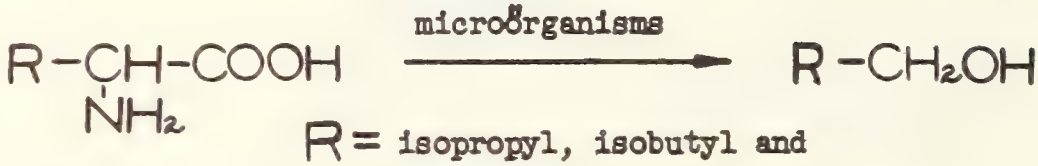
Rx. 977



leucine — 3-methyl-1-butanol

Ehrlich, U.S. 885,591 (April 21, 1908).
C.A. 2, 2599[9] (1908).

Rx. 978

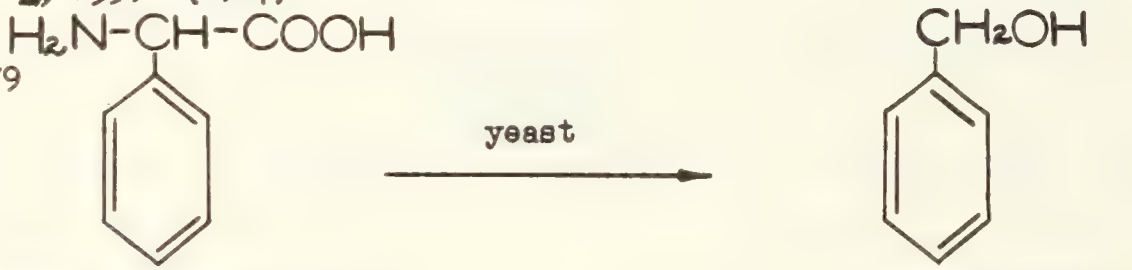


leucine, isoleucine and isovaleric acid mixture

fusel oil

Ehrlich, Ber. 40B, 1027-47 (1907).
C.A. 1, 1539[6] (1907).

Rx. 979

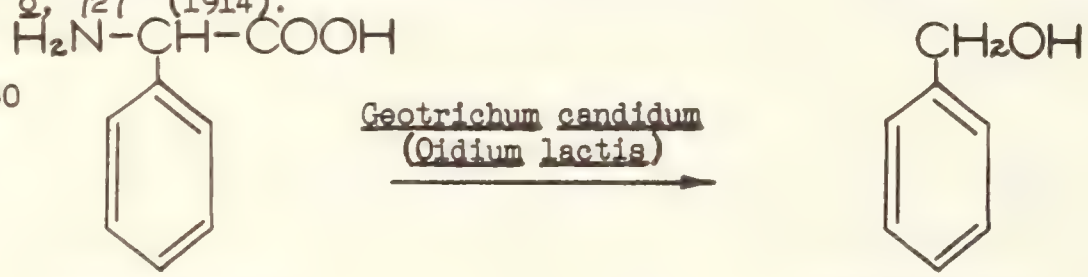


phenylaminoacetic acid (phenylglycine)

benzyl alcohol

Horsters, Chem. Ztg. 37, 74 (1913).
C.A. 8, 727[1] (1914).

Rx. 980

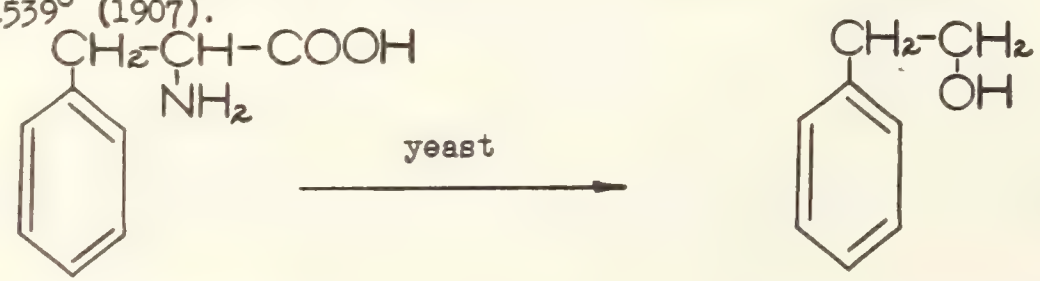


phenylglycine

benzyl alcohol (7.8%)

Ehrlich, Ber. 40B, 1027-47 (1907).
C.A. 1, 1539[6] (1907).

Rx. 981



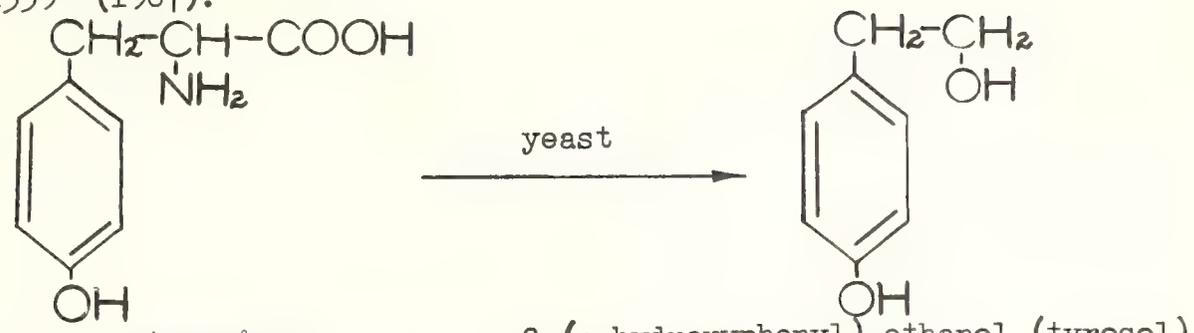
phenylalanine

β-phenylethanol

Ehrlich, Ber. 40B, 1027-47 (1907).

C.A. 1, 1539[6] (1907).

Rx. 982

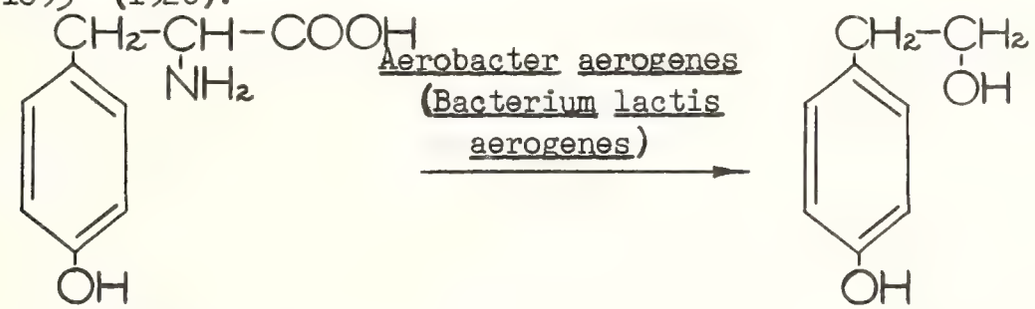


tyrosine — β-(p-hydroxyphenyl)-ethanol (tyrosol)

Hirai, Acta Schol. Med. Univ. Kioto 2, 425-32 (1918).

C.A. 14, 1695[1] (1920).

Rx. 983

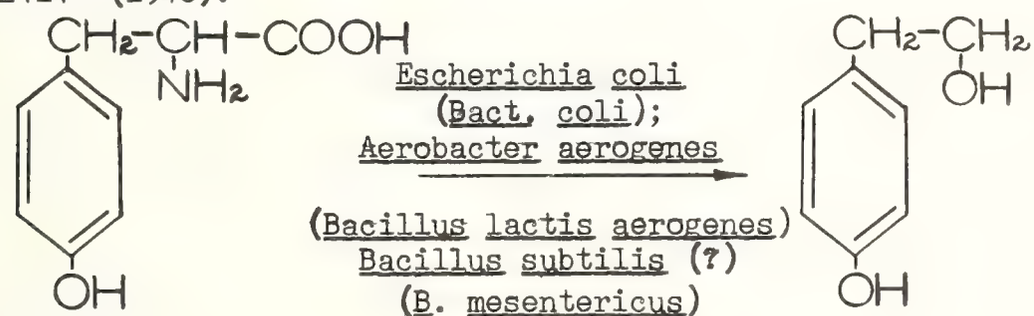


l-tyrosine — tyrosol

Grimmer and Wauschkuhn, Milchw. Forsch. 20, 110-30 (1939).

C.A. 34, 2414[5] (1940).

Rx. 984

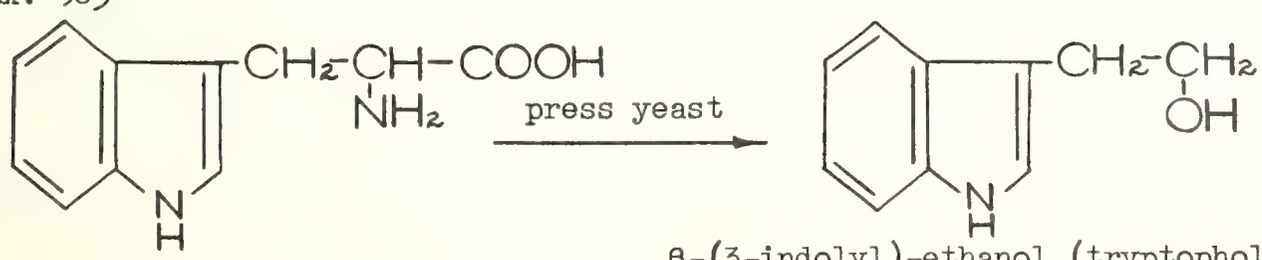


tyrosine — tyrosol

Ehrlich, Ber. 45B, 883-9 (1912).

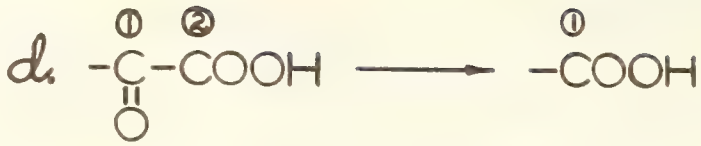
C.A. 6, 2427[3] (1912).

Rx. 985



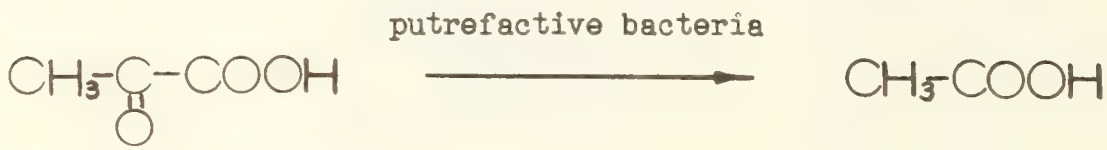
tryptophane — β-(3-indolyl)-ethanol (tryptophol) (80%)

III. Decarboxylation



Neuberg, Biochem. Z. 67, 90-101 (1914).
C.A. 9, 4728 (1915).

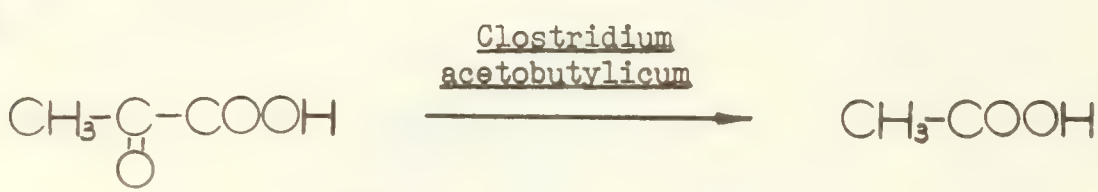
Rx. 986



pyruvic acid — acetic acid

Peterson and Johnson, J. Bacteriol. 25, 69 (1933).
C.A. 27, 19811 (1933).

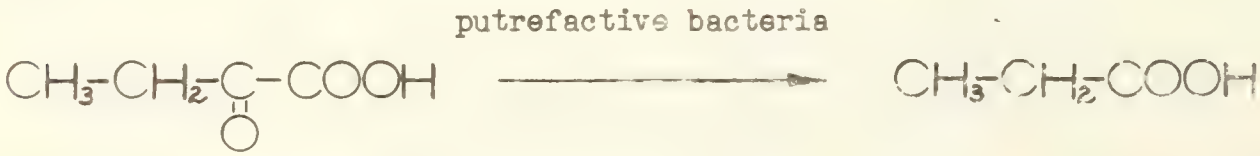
Rx. 987



pyruvic acid — acetic acid

Neuberg, Biochem. Z. 67, 122-6 (1914).
C.A. 9, 4729 (1915).

Rx. 988



α-ketobutyric acid — propionic acid

Neuberg and Ringer, Biochem. Z. 71, 226-36 (1915).

C.A. 9, 3059[7] (1915).

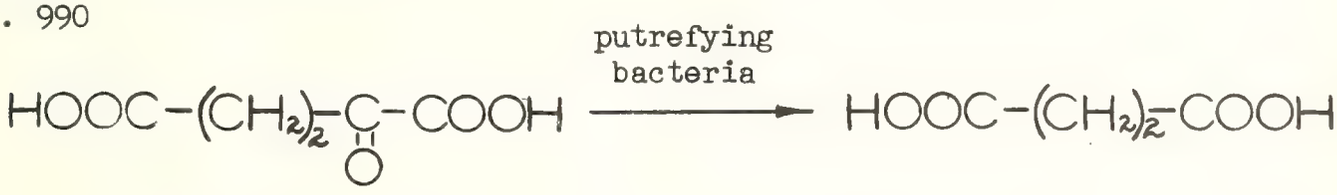
Rx. 989

α-ketoglutaric acid — succinic acid (99%)

Neuberg and Ringer, Biochem. Z. 71, 237-44 (1915).

C.A. 9, 3059[7] (1915).

Rx. 990

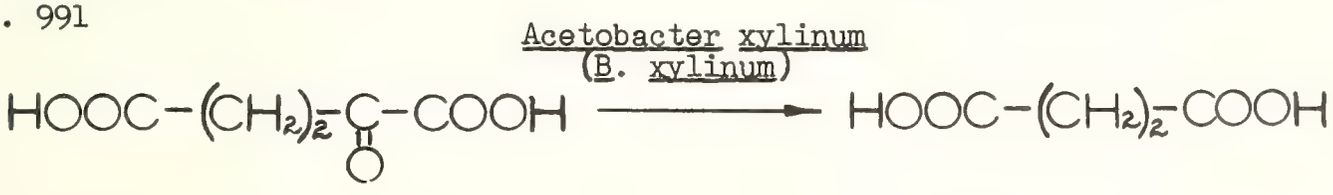


α-ketoglutaric acid — succinic acid (13-19%)

Iwatsuru, Biochem. Z. 168, 34-5 (1926).

C.A. 20, 2179[2] (1926).

Rx. 991

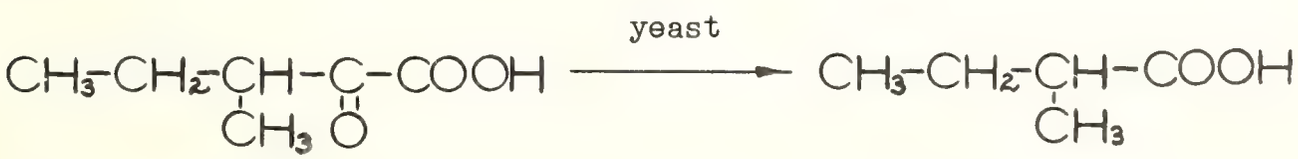


α-ketoglutaric acid — succinic acid

Neuberg and Peterson, Biochem. Z. 67, 32-45 (1914).

C.A. 9, 472[4] (1915).

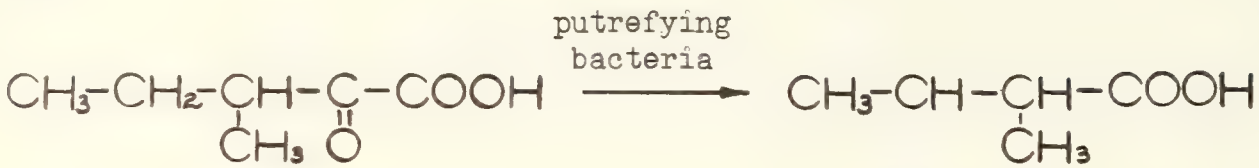
Rx. 992



α-keto-β-methyl-n-valeric acid (methylethylpyroracemic acid) — α-methylbutyric acid

Neuberg and Rewald, Biochem. Z. 71, 122-5 (1915).
C.A. 9, 3058[7] (1915).

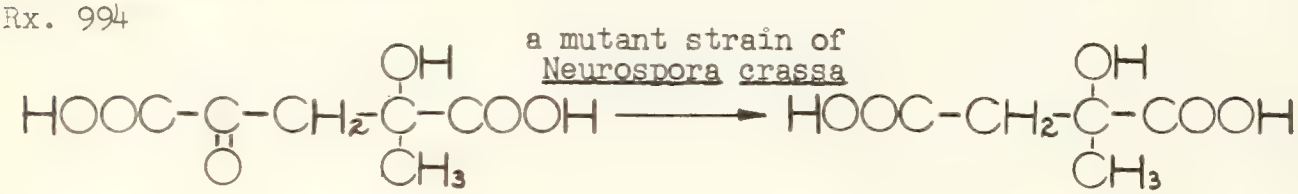
Rx. 993



α-keto-β-methyl-n-valeric acid — α-methylbutyric acid

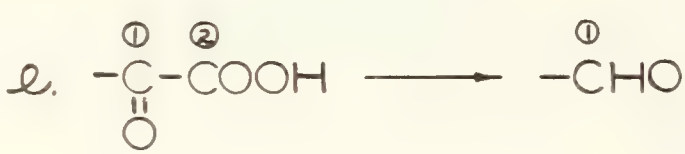
Willson and Adelberg, J. Biol. Chem. 229, 1011-8 (1957).
C.A. 52, 7430c (1958).

Rx. 994



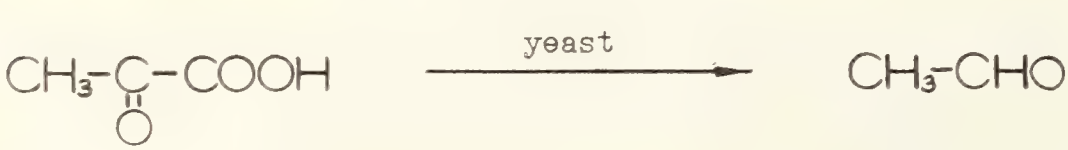
γ-hydroxy-γ-methyl-α-ketoglutaric acid — citramalic acid

III. Decarboxylation



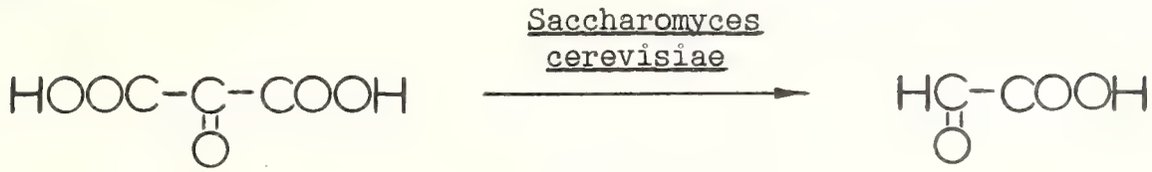
Neuberg and Kerb, Biochem. Z. 53, 406-19 (1913). See ibid. 43, 491-9 (1912).
Brit. C.A. 104 [ii], 1026 (1913).

Rx. 995



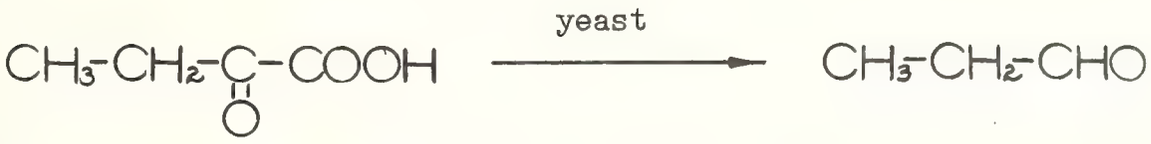
pyruvic acid — acetaldehyde

Brunel-Capelle, Compt. rend. 233, 1480-1 (1951).
C.A. 46, 4605b (1952).
Rx. 996



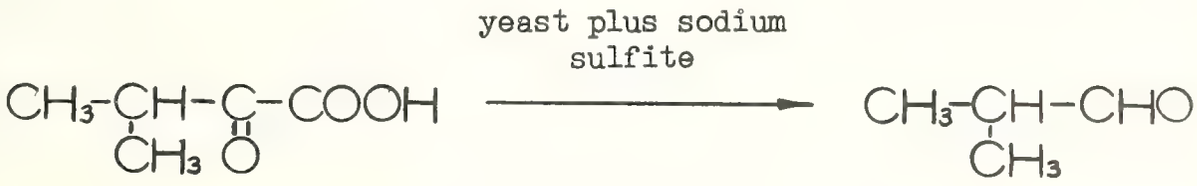
mesoxalic acid — glyoxylic acid

Neuberg and Kerb, Biochem. Z. 47, 413-20 (1912).
C.A. 7, 1728[3] (1913).
Rx. 997



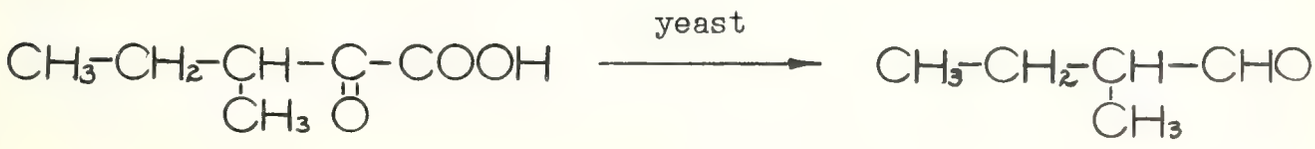
α-ketobutyric acid — propionaldehyde (4.2%)

Sen, Biochem. Z. 143, 195-200 (1923).
C.A. 18, 2181[2] (1924).
Rx. 998



α-keto-β-methylbutyric acid — α-methylpropionaldehyde (75%)

Neuberg and Peterson, Biochem. Z. 67, 32-45 (1914).
C.A. 9, 472[4] (1915).
Rx. 999

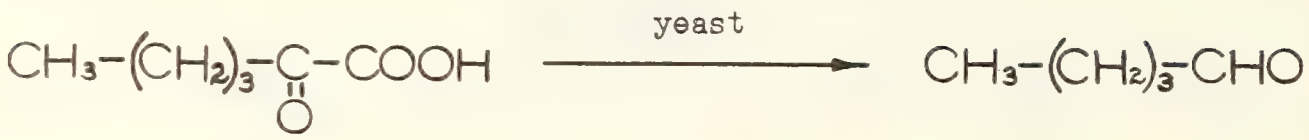


α-keto-β-methylvaleric acid (methylethylpyroracemic acid) — α-methylbutyraldehyde

Sen, Biochem. Z. 140, 447-52 (1923).

C.A. 18, 1305[9] (1924).

Rx. 1000



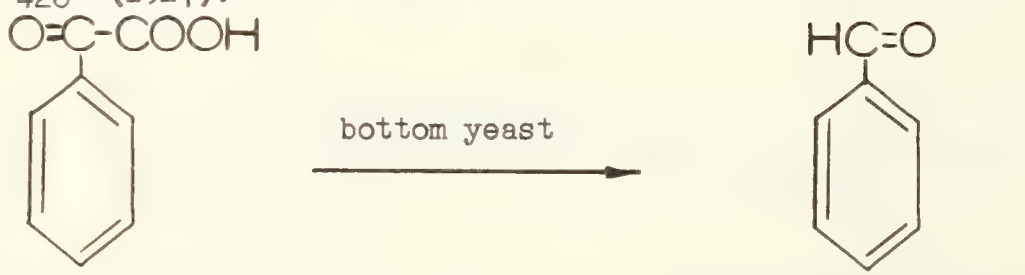
α-keto-n-caproic acid

n-valeraldehyde (70%)

Binder-Kotrba, Biochem. Z. 174, 440-2 (1926).

C.A. 21, 426[2] (1927).

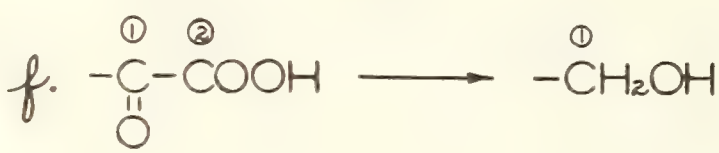
Rx. 1001



phenylglyoxylic acid

benzaldehyde (62%)

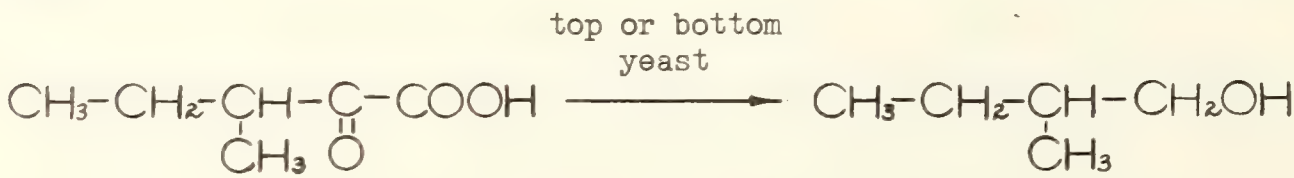
III. Decarboxylation



Neuberg and Peterson, Biochem. Z. 67, 32-45 (1914).

C.A. 9, 472[4] (1915).

Rx. 1002



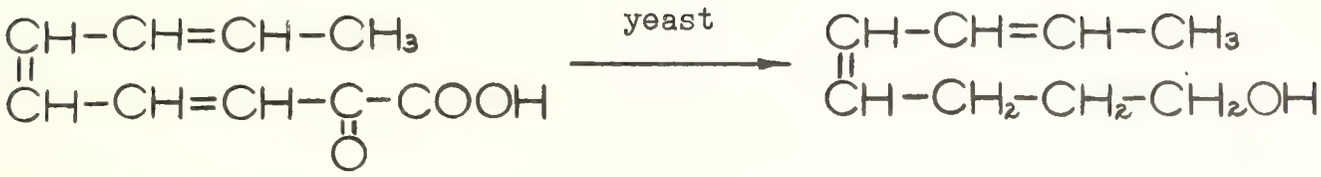
α-keto-β-methyl-n-valeric acid
(methylethylpyroracemic acid)

2-methyl-1-butanol

Fischer and Wiedemann, Ann. 522, 1-16 (1936).

C.A. 30, 3780[6] (1936).

Rx. 1003

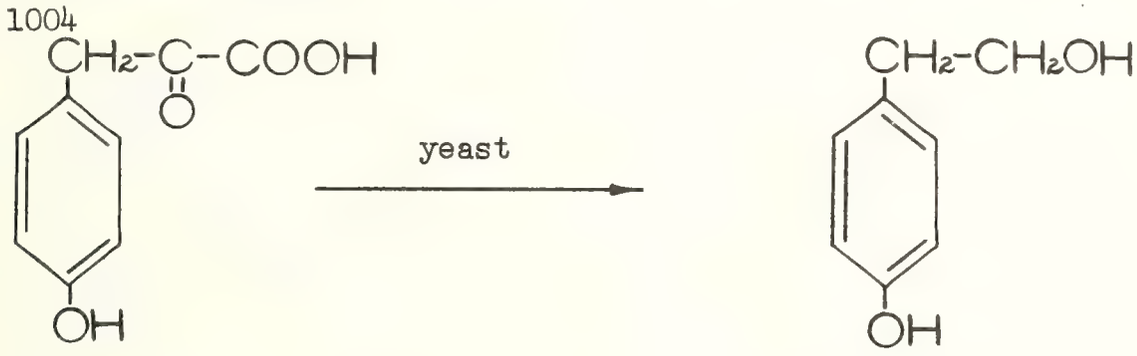


2-keto-3,5,7-nonatrienoic acid — 4,6-octadiene-1-ol

Neubauer and Fromherz, Z. physiol. Chem. 70, 326-50 (1911).

C.A. 5, 1789[6] (1911).

Rx. 1004

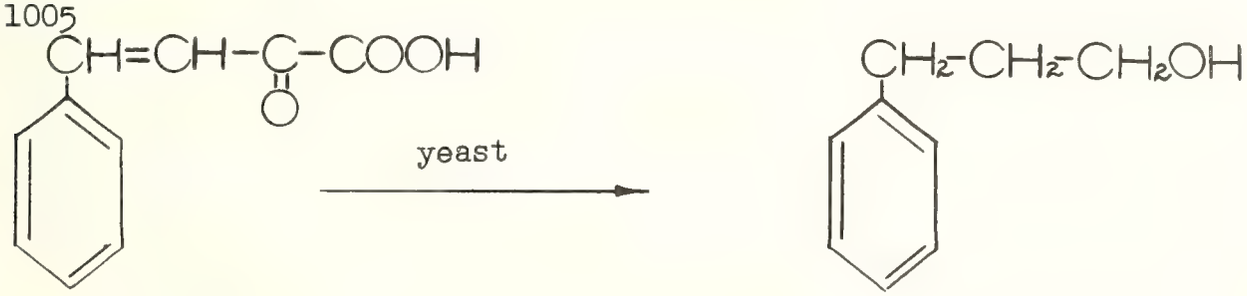


p-hydroxyphenylpyruvic acid — β-(p-hydroxyphenyl)-ethanol (32%)

Fischer and Wiedemann, Ann. 513, 260-80 (1934).

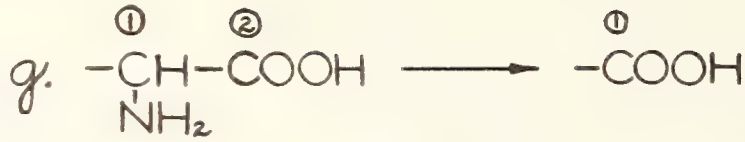
C.A. 29, 1383[9] (1935).

Rx. 1005



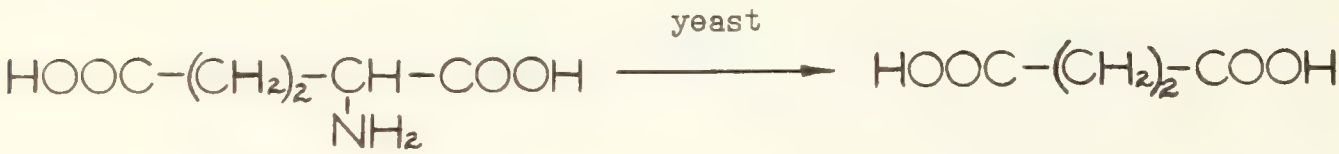
benzalpyruvic acid — 3-phenyl-1-propanol (75%)

III. Decarboxylation



Ehrlich, Z. Spiritusind. 30, 327 (1907).
Brit. C.A. 94 [ii], 416 (1908).

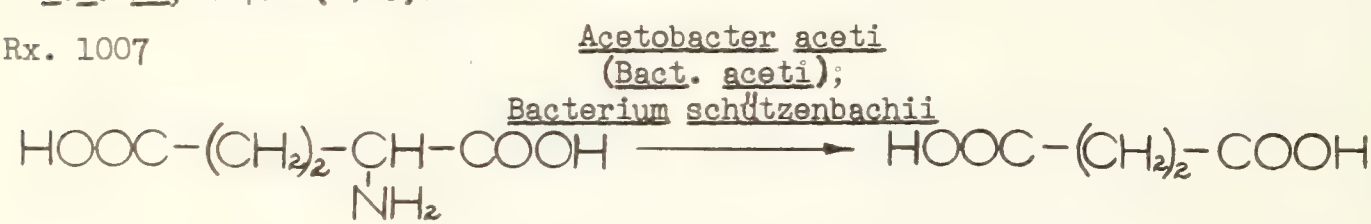
Rx. 1006



glutamic acid — succinic acid (87.5%)

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).
C.A. 20, 2870[9] (1926).

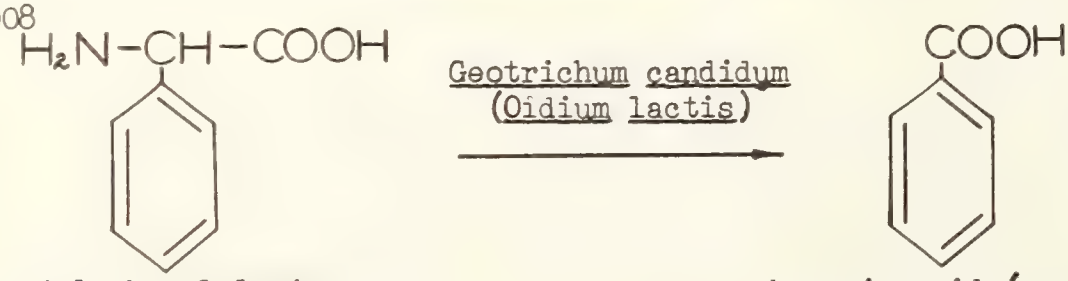
Rx. 1007



glutamic acid — succinic acid

Chikano and Kitano, Z. physiol. Chem. 164, 217-25 (1927).
C.A. 21, 1662[1] (1927).

Rx. 1008



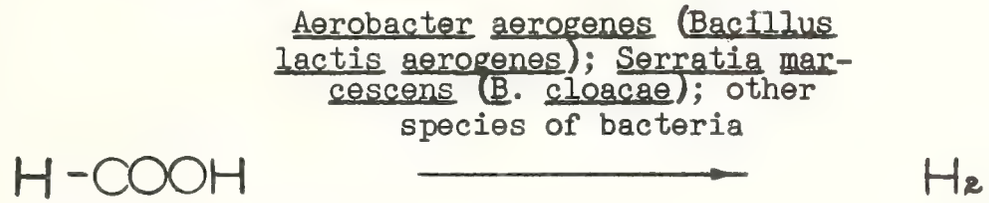
d,l-phenylglycine — benzoic acid (approx. 8%)

III. Decarboxylation

h. Miscellaneous types

Pakes and Jollyman, J. Chem. Soc. 79, 386-91 (1901).

Rx. 1009

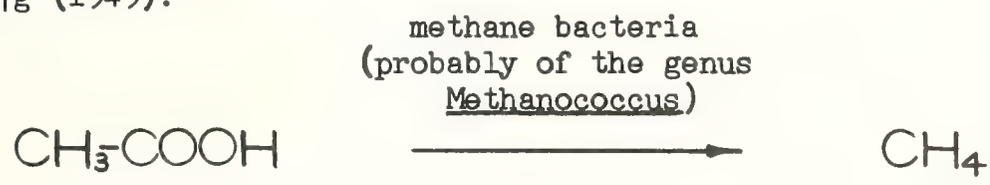


formic acid (Na salt) — hydrogen

Stadtman and Barker, Arch. Biochem. 21, 256-64 (1949).

C.A. 43, 7187g (1949).

Rx. 1010

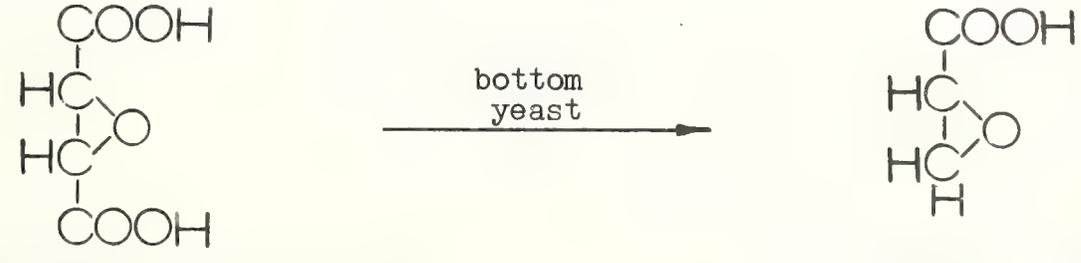


acetic acid — methane

Kuhn and Ebel, Ber. 58B, 1447-9 (1925).

C.A. 20, 3678 (1926).

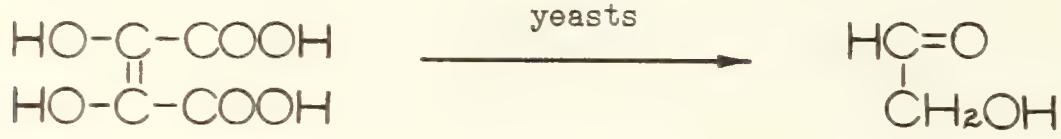
Rx. 1011



ethylene oxide-α,β-dicarboxylic acid — glycidic acid

Neuberg and Schwenk, Biochem. Z. 71, 104-13 (1915).
C.A. 9, 3076[6] (1915).

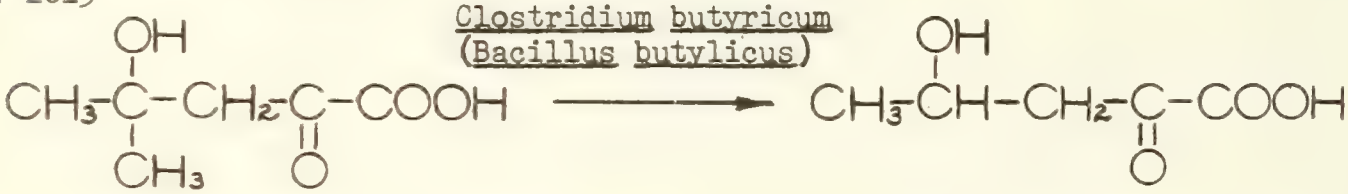
Rx. 1012



dihydroxymaleic acid — glycolic aldehyde

Neuberg and Arinstein, Biochem. Z. 117, 269-314 (1921).
C.A. 15, 3122[8] (1921).

Rx. 1013

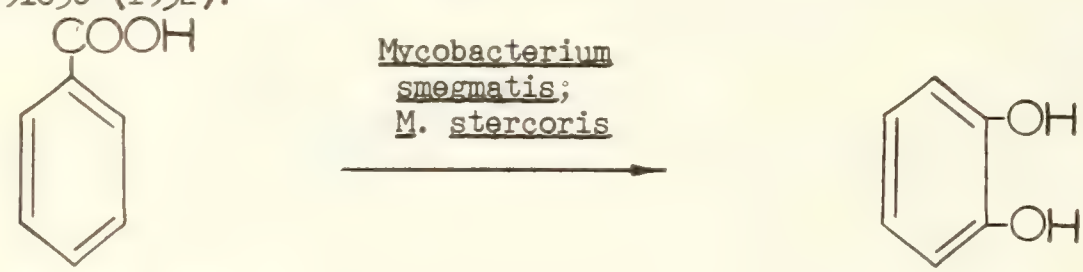


α-keto-γ-hydroxy-γ-methylglutaric acid (pyruvic acid aldol) — α-keto-γ-hydroxy-n-valeric acid

---

Gale, J. Bacteriol. 64, 131-5 (1952).
C.A. 46, 9163e (1952).

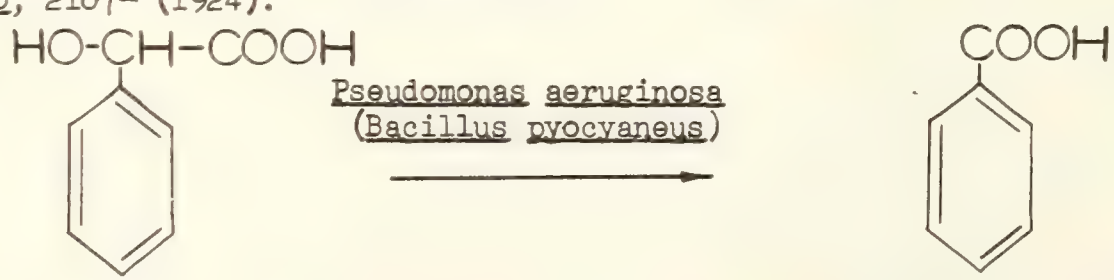
Rx. 1014



benzoic acid — catechol

Supniewski, Compt. rend. soc. biol. 90, 1111-12 (1924).
C.A. 18, 2187[1] (1924).

Rx. 1015

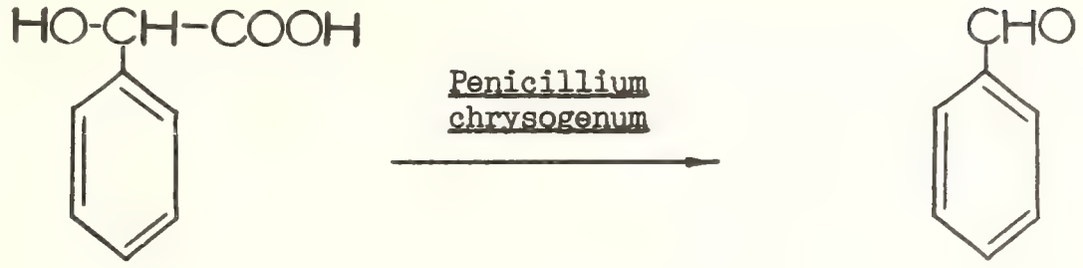


mandelic acid — benzoic acid

Hockenhull et al., Biochem. J. 50, 605-9 (1952).

C.A. 46, 5129d (1952).

Rx. 1016

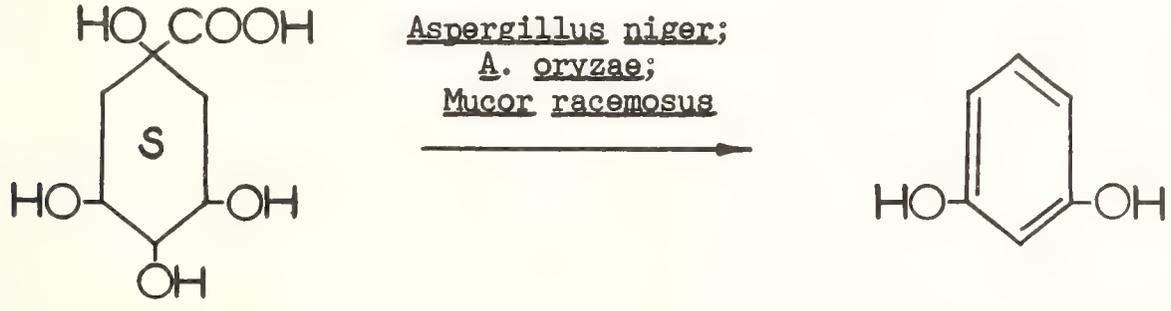


D,L-mandelic acid — benzaldehyde

Butkewitsch, Biochem. Z. 145, 442-60 (1924).

C.A. 19, 915 (1925).

Rx. 1017

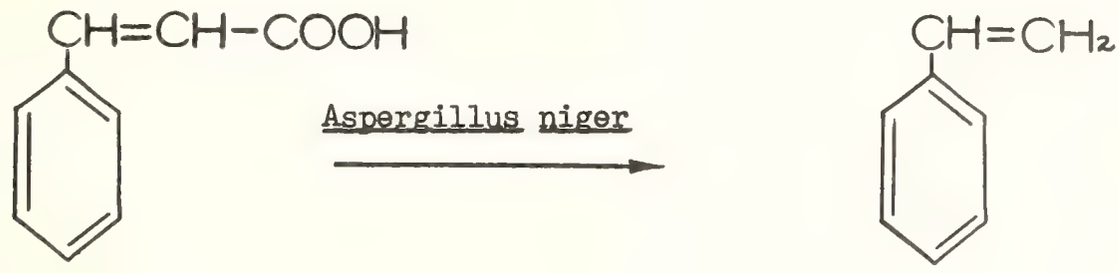


quinic acid — resorcinol

Herzog and Ripke, Z. physiol. Chem. 57, 43-5 (1908).

C.A. 3, 15378 (1909).

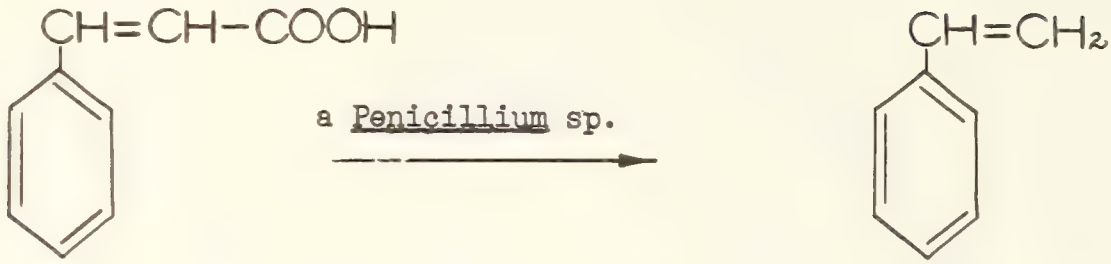
Rx. 1018



cinnamic acid (ammonium salt) — styrene

Jaminet, J. pharm. Belg. [N.S.] 5, 191-201 (1950).
C.A. 44, 11029e (1950).

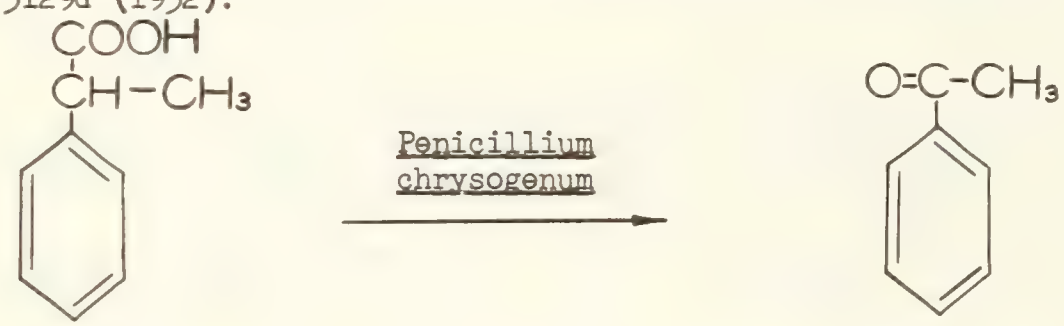
Rx. 1019



cinnamic acid — styrene

Hockenhull et al., Biochem. J. 50, 605-9 (1952).
C.A. 46, 5129d (1952).

Rx. 1020



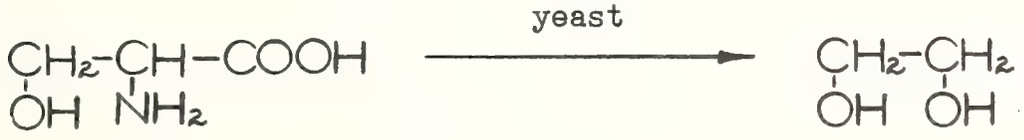
hydratropic acid — acetophenone

IV. Deamination

Ehrlich, Biochem. Z. 8, 438-66 (1908).

C.A. 2, 2568[2] (1908).

Rx. 1021



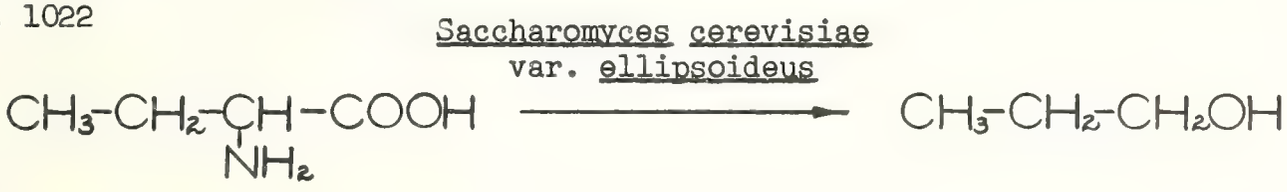
d,1-serine

1,2-ethanediol
(ethylene glycol)

Kepner, et al., Arch. Biochem. Biophys. 51, 88-93 (1954).

C.A. 48, 10991b (1954).

Rx. 1022



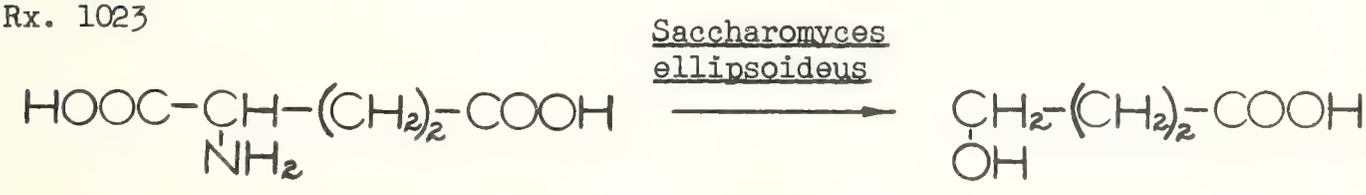
α-amino-n-butyric acid

1-propanol (2.8%)

Antoniani and Cioffi, Ann. chim. applicata 38, 429-33 (1948).

C.A. 43, 7541f (1949).

Rx. 1023

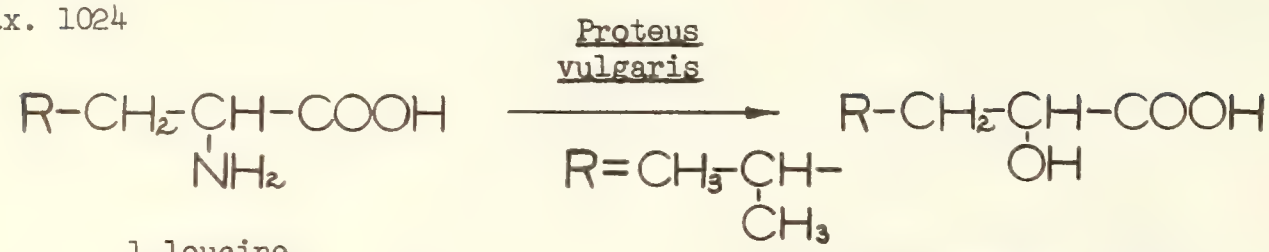


glutamic acid

γ-hydroxybutyric acid

Arai, Biochem. Z. 122, 251-7 (1921).
C.A. 16, 945[5] (1922).

Rx. 1024

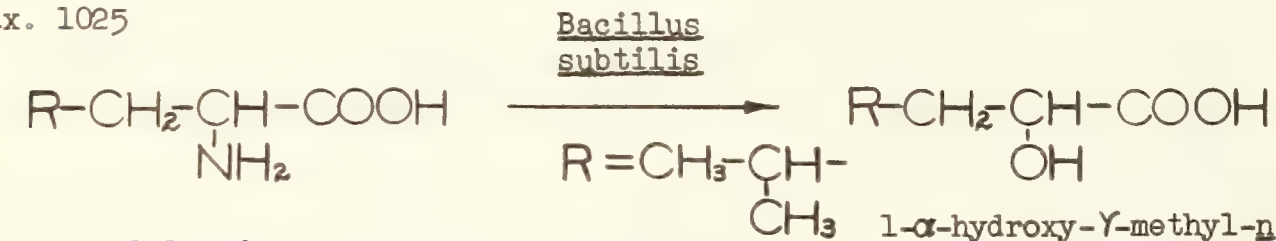


l-leucine

d-α-hydroxy-γ-methyl-n-valeric acid (40%) (d-leucinic acid)

Arai, Biochem. Z. 122, 251-7 (1921).
C.A. 16, 945[5] (1922).

Rx. 1025

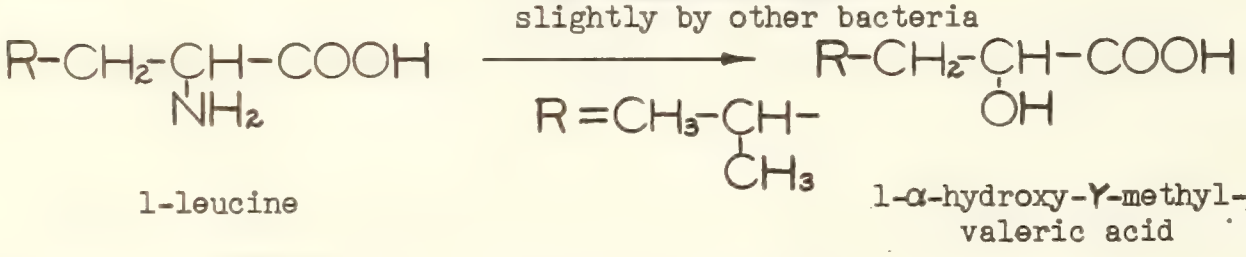


l-leucine

l-α-hydroxy-γ-methyl-n-valeric acid (12%) (l-leucinic acid)

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).
C.A. 20, 2870[9] (1926). Acetobacter rancens (Bact. rancens); Bacterium xylinoides; B. schützenbachii; slightly by other bacteria

Rx. 1026

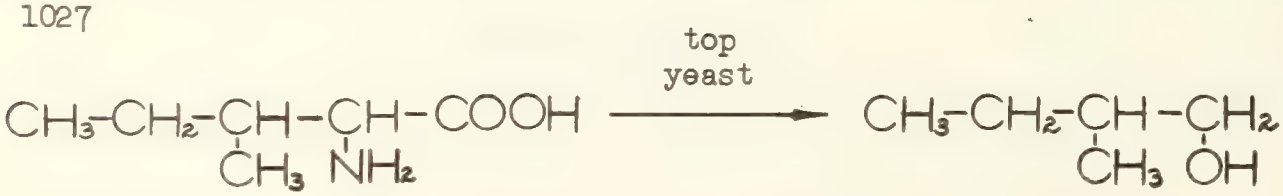


l-leucine

l-α-hydroxy-γ-methyl-n-valeric acid

Ehrlich, Ber. 40B, 1027-47 (1907). See ibid. 40B, 2538-62 (1907).
C.A. 1, 1539[6] (1907).

Rx. 1027

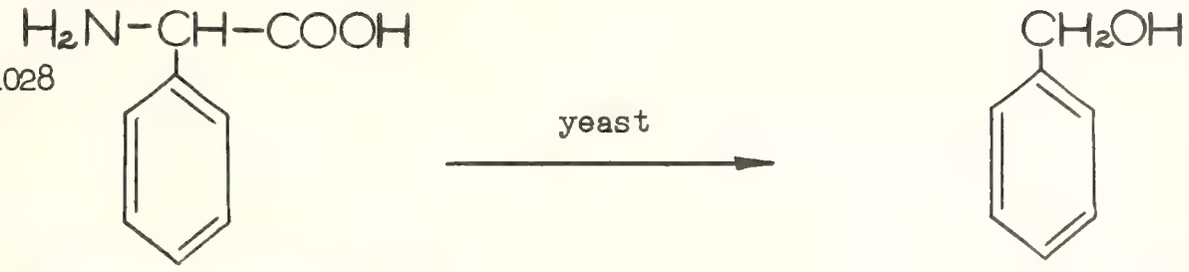


isoleucine

l-2-methyl-1-butanol (l-amyl alcohol)

Ehrlich, Ber. 40B, 1027-47 (1907).
C.A. 1, 1539[6] (1907).

Rx. 1028

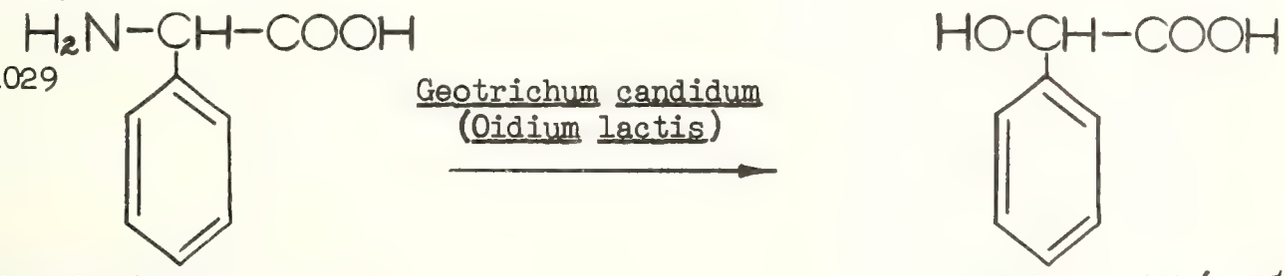


phenylaminoacetic acid (phenylglycine)

benzyl alcohol

Horsters, Chem. Ztg. 37, 74 (1913).
C.A. 8, 727[1] (1914).

Rx. 1029

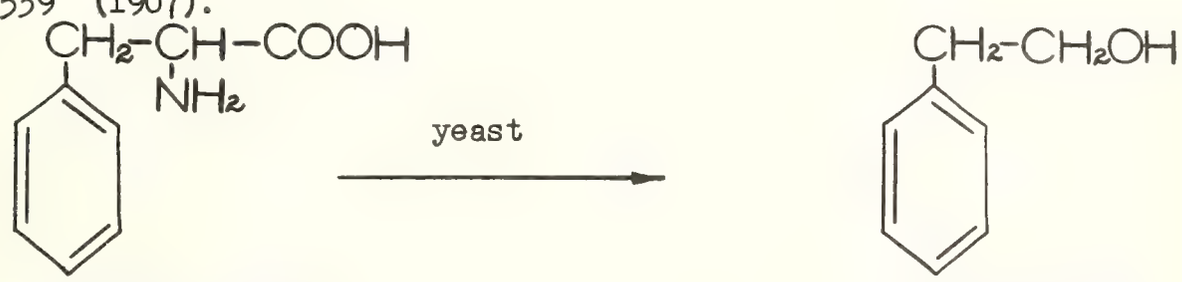


phenylaminoacetic acid (phenylglycine)

mandelic acid (1.7%)

Ehrlich, Ber. 40B, 1027-47 (1907).
C.A. 1, 1539[6] (1907).

Rx. 1030

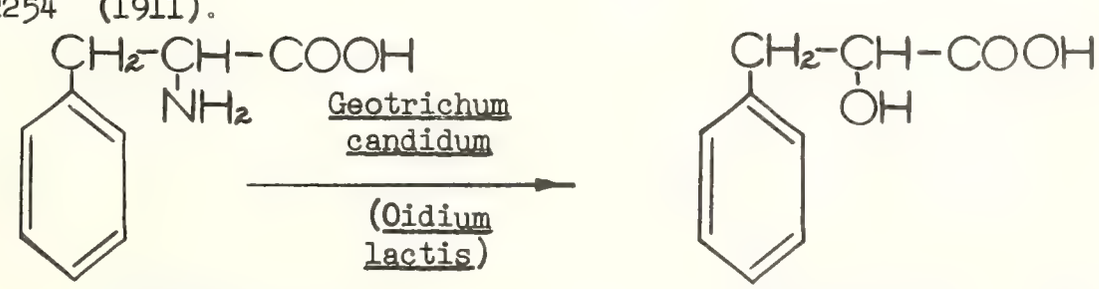


phenylalanine

β-phenylethanol

Ehrlich and Jacobsen, Ber. 44B, 888-97 (1911).
C.A. 5, 2254[2] (1911).

Rx. 1031

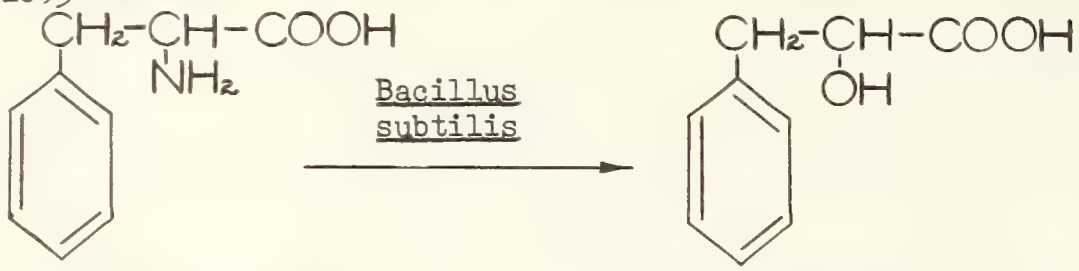


d,l-phenylalanine

d-β-phenyllactic acid (33%)

Amatsu and Tsudji, Acta Schol. Med. Univ. Kioto 2, 447-57 (1918).
C.A. 14, 1695[4] (1920).

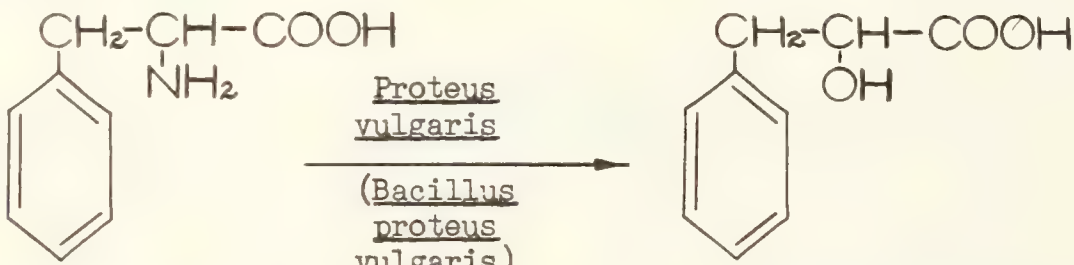
Rx. 1032



d,l-phenylalanine → l-β-phenyllactic acid

Amatsu and Tsudji, Acta Schol. Med. Univ. Kioto 2, 447-57 (1918).
C.A. 14, 1695[4] (1920).

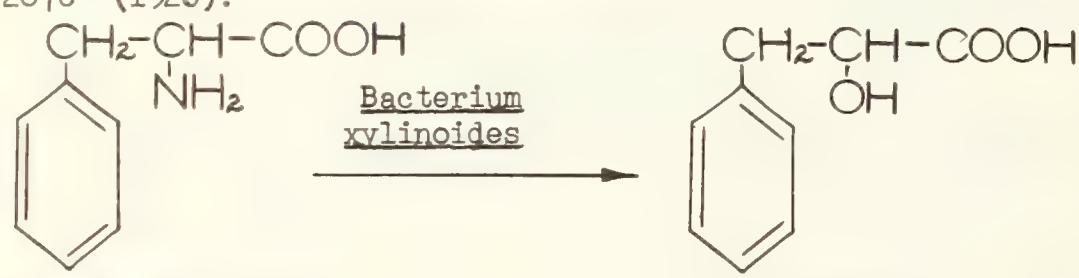
Rx. 1033



d,l-phenylalanine → d-phenyllactic acid

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).
C.A. 20, 2870[9] (1926).

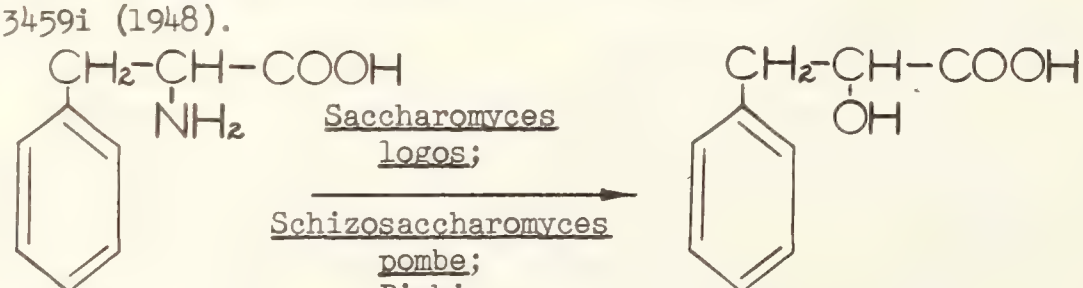
Rx. 1034



d,l-phenylalanine → l-phenyllactic acid

Uemura, J. Agr. Chem. Soc. Japan 20, 295-303 (1944).
C.A. 42, 3459i (1948).

Rx. 1035

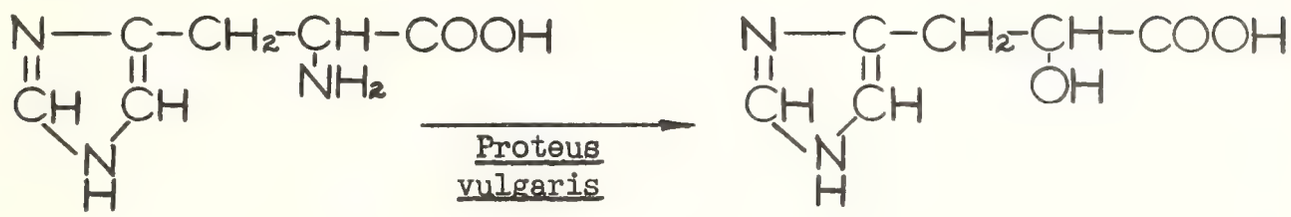


phenylalanine → β-phenyllactic acid

Hirai, Acta Schol. Med. Univ. Kioto 3, 49-53 (1919).

C.A. 14, 1694[9] (1920).

Rx. 1036

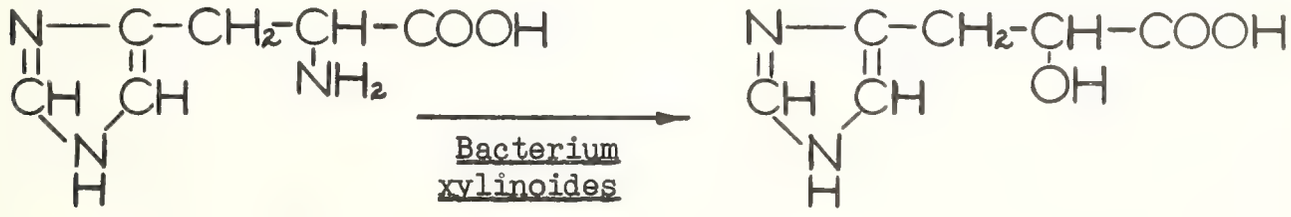


l-histidine hydrochloride — d-β-imidazolyllactic acid (11%)

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).

C.A. 20, 2870[9] (1926).

Rx. 1037

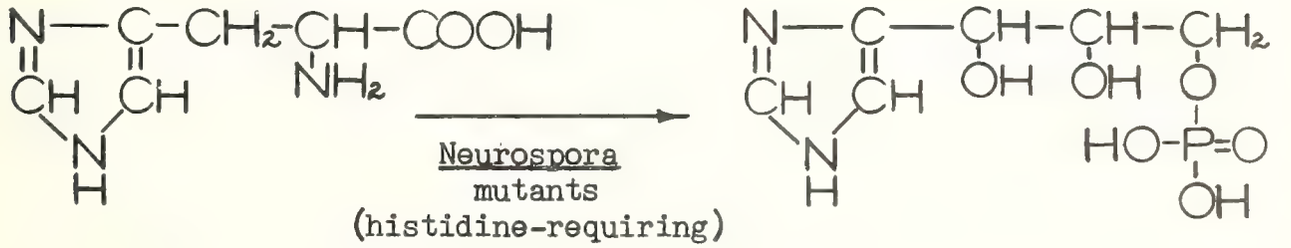


l-histidine — l-β-imidazolyllactic acid

Ames and Mitchell, J. Biol. Chem. 212, 687-96 (1955).

C.A. 49, 7057h (1955).

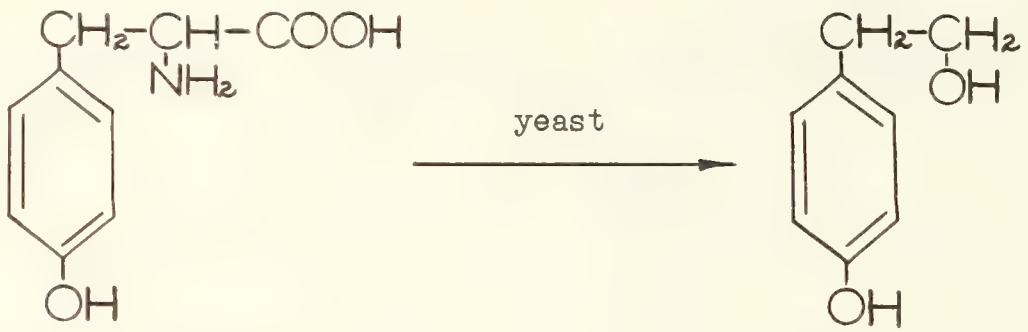
Rx. 1038



histidine — D-erythro-imidazole-glycerol phosphate

Ehrlich, Ber. 40B, 1027-47 (1907). See Ber. 44B, 139-46 (1911).
C.A. 1, 1539[6] (1907).

Rx. 1039

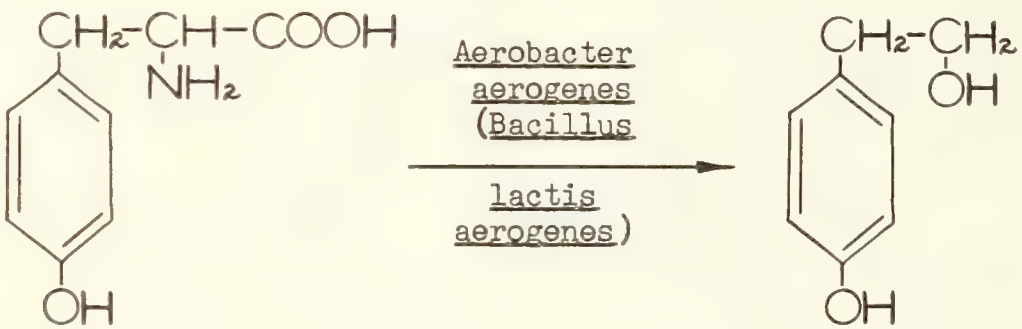


tyrosine

β-(p-hydroxyphenyl)-ethanol
(tyrosol)

Hirai, Acta Schol. Med. Univ. Kioto 2, 425-32 (1918).
C.A. 14, 1695[1] (1920).

Rx. 1040

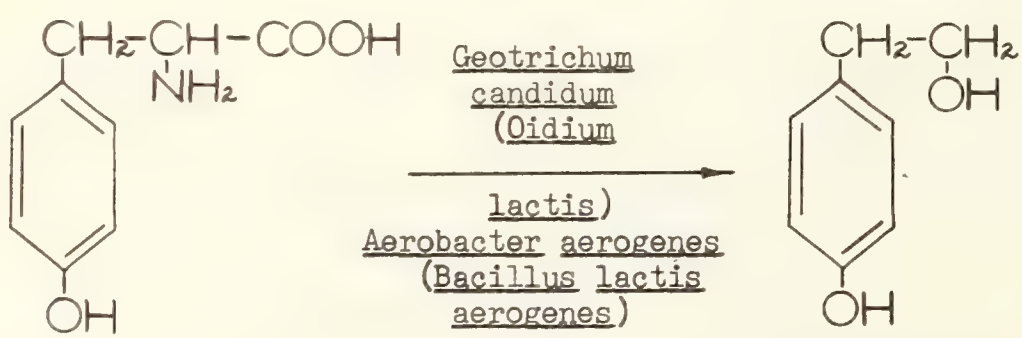


l-tyrosine

tyrosol

Grimmer and Wauschkuhn, Milchw. Forsch. 20, 110-30 (1939).
C.A. 34, 2414[5] (1940).

Rx. 1041



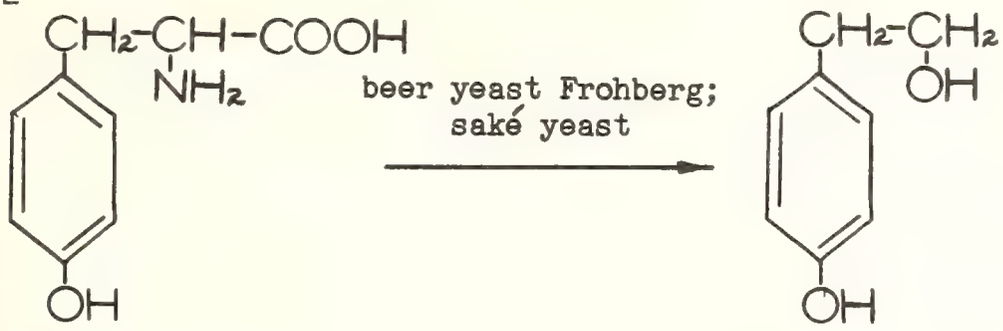
tyrosine

tyrosol

Uemura, J. Agr. Chem. Soc. Japan 20, 295-303 (1944).

C.A. 42, 3459i (1948).

Rx. 1042



L-tyrosine

tyrosol

Ehrlich and Jacobsen, Ber. 44B, 888-97 (1911).

C.A. 5, 2254[2] (1911).

Rx. 1043

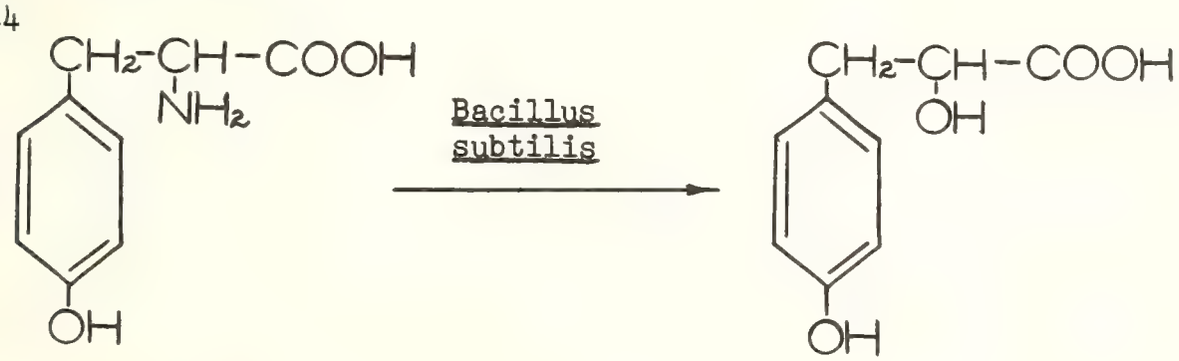
l-tyrosine

d-p-hydroxyphenyllactic acid
(90%)

Tsudji, Acta Schol. Med. Univ. Kioto 2, 115-23 (1918).

C.A. 12, 1889[4] (1918).

Rx. 1044



tyrosine

l-p-hydroxyphenyllactic acid

Tsudji, Acta Schol. Med. Univ. Kioto 2, 115-23 (1918).
C.A. 12, 1889[4] (1918).

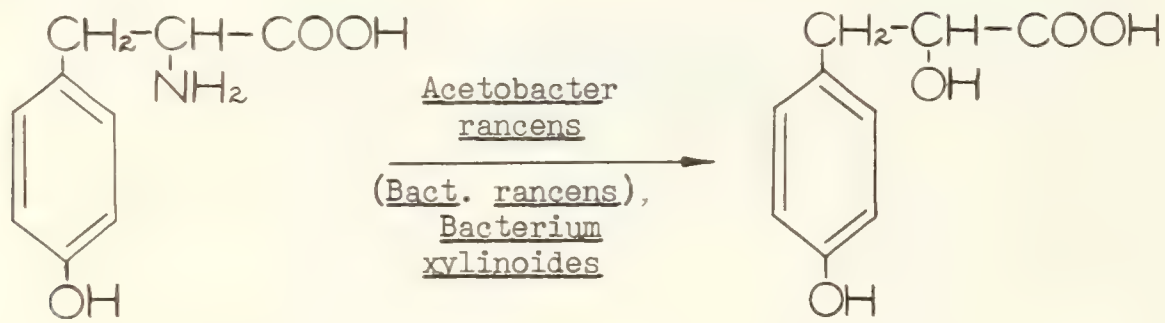
Rx. 1045

tyrosine

d-p-hydroxyphenyllactic acid
(approx. 40% of tyrosine used)

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).
C.A. 20, 2870[9] (1926).

Rx. 1046

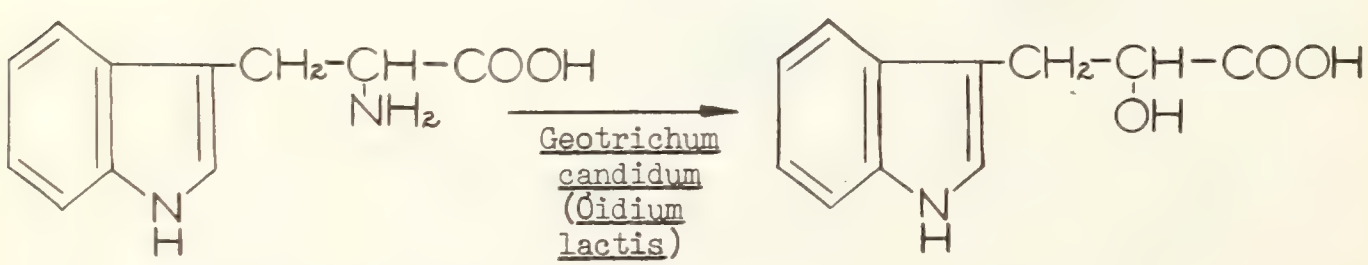


l-tyrosine

l-p-hydroxyphenyllactic acid

Ehrlich and Jacobsen, Ber. 44B, 888-97 (1911).
C.A. 5, 2254[2] (1911).

Rx. 1047



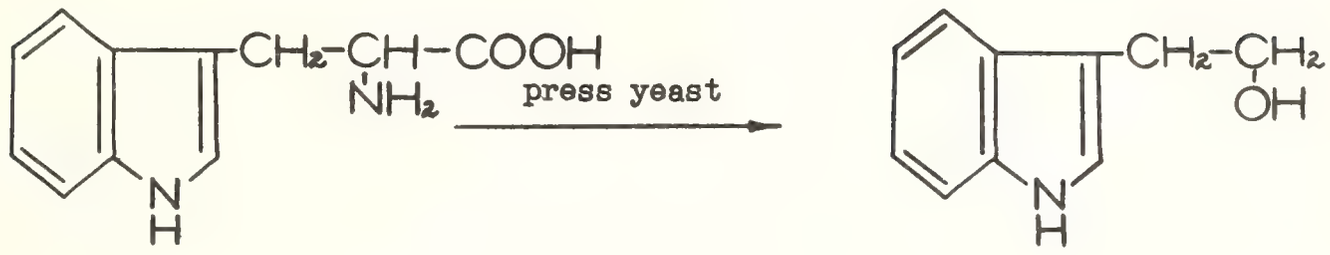
l-tryptophane

l-β-(3-indolyl)-lactic acid
(42.5%)

Ehrlich, Ber. 45B, 883-9 (1912).

C.A. 6, 2427[3] (1912).

Rx. 1048



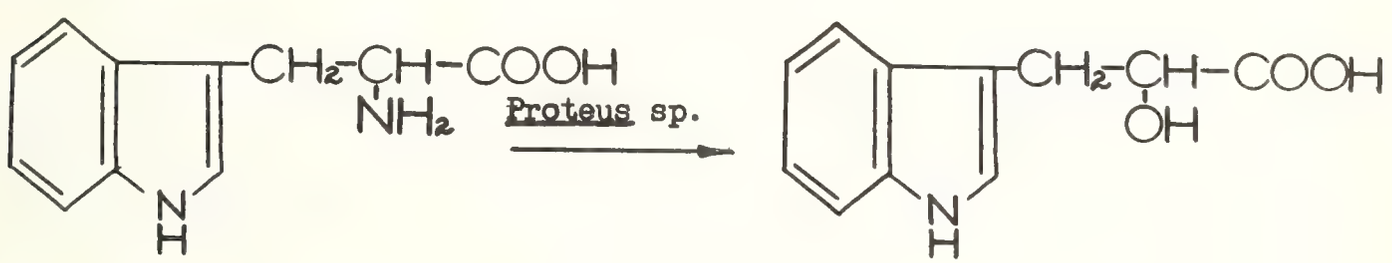
tryptophane

tryptophol (80%)

Sasaki and Otsuka, Biochem. Z. 121, 167-70 (1921).

C.A. 15, 3654[6] (1921).

Rx. 1049



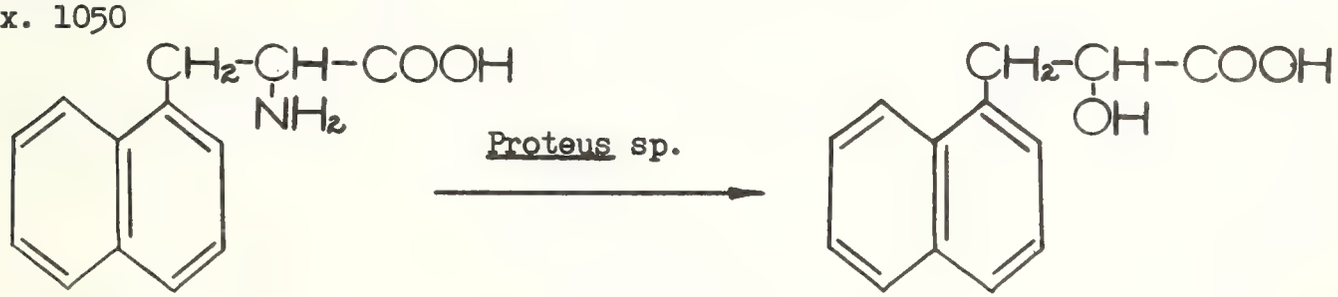
l-tryptophane

d-β-(3-indolyl)-lactic acid

Sasaki and Kinose, Biochem. Z. 121, 171-4 (1921).

C.A. 16, 1261[1] (1922).

Rx. 1050



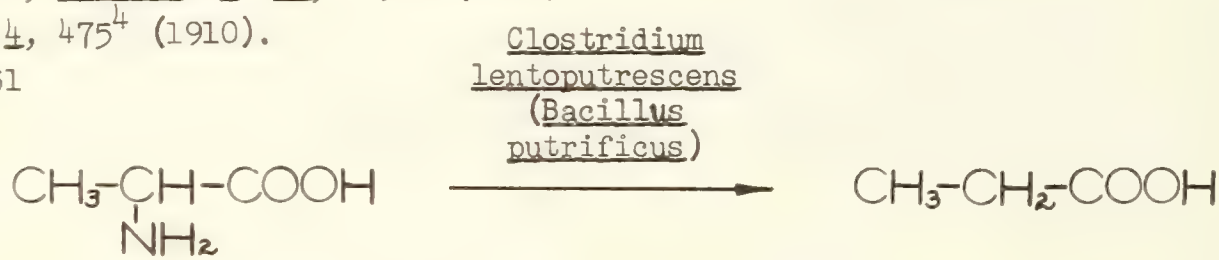
3-(α-naphthyl)-alanine

3-(α-naphthyl)-lactic acid

IV. Deamination

Brasch, Biochem. Z. 22, 403-8 (1909).
C.A. 4, 475[4] (1910).

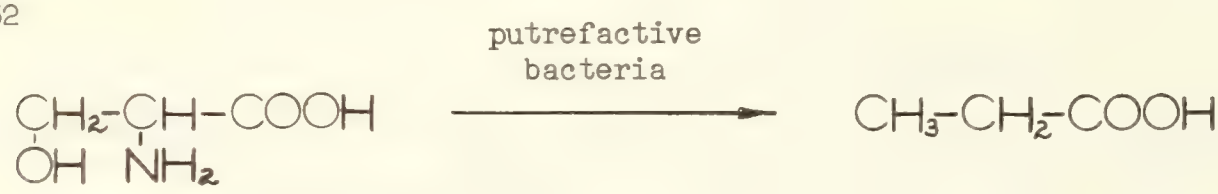
Rx. 1051



alanine → propionic acid

Brasch, Biochem. Z. 22, 403-8 (1909).
C.A. 4, 475[4] (1910).

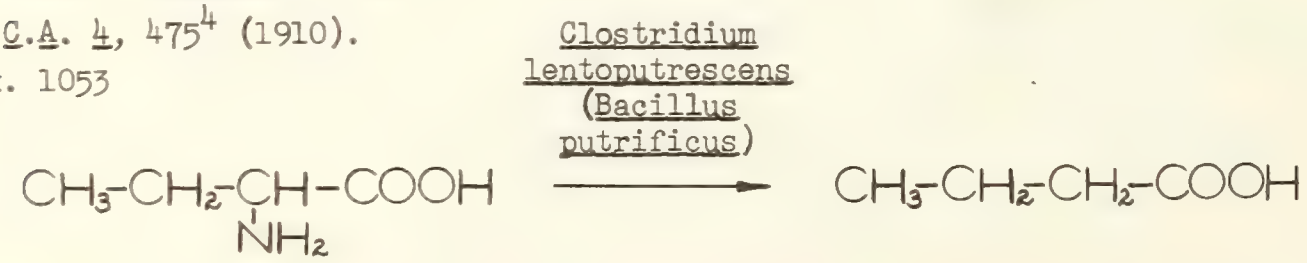
Rx. 1052



serine → propionic acid

Brasch, Biochem. Z. 22, 403-8 (1909).
C.A. 4, 475[4] (1910).

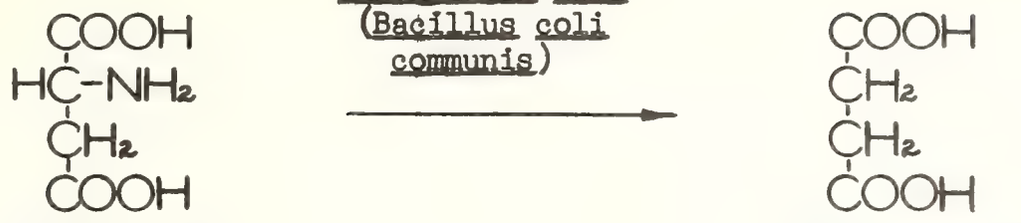
Rx. 1053



α (?)-aminobutyric acid → butyric acid

Harden, J. Chem. Soc. 79, 610-28 (1901).

Rx. 1054

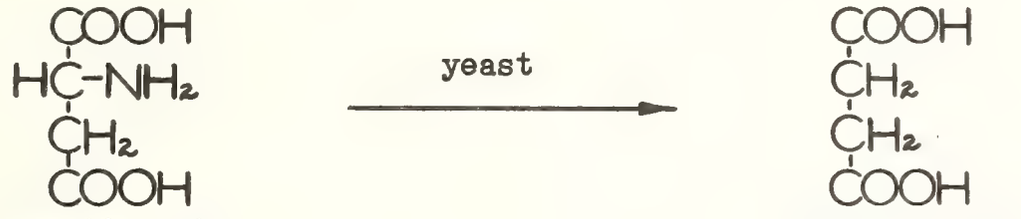


aspartic acid → succinic acid

Ehrlich, Z. Spiritusind. 30, 327 (1907).

Brit. C.A. 94 [ii], 416 (1908).

Rx. 1055

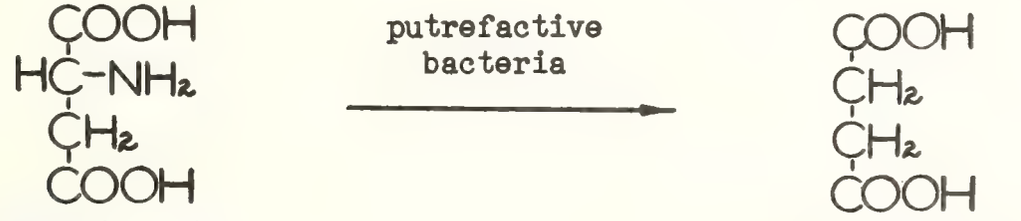


aspartic acid → succinic acid

Brasch, Biochem. Z. 22, 403-8 (1909).

C.A. 4, 475[4] (1910).

Rx. 1056

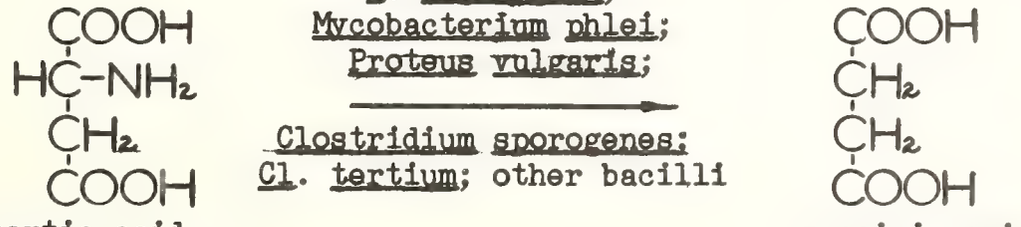


aspartic acid → succinic acid (approx. 4%)

Cook and Woolf, Biochem. J. 22, 474-81 (1928).

C.A. 22, 2960[5] (1928).

Rx. 1057

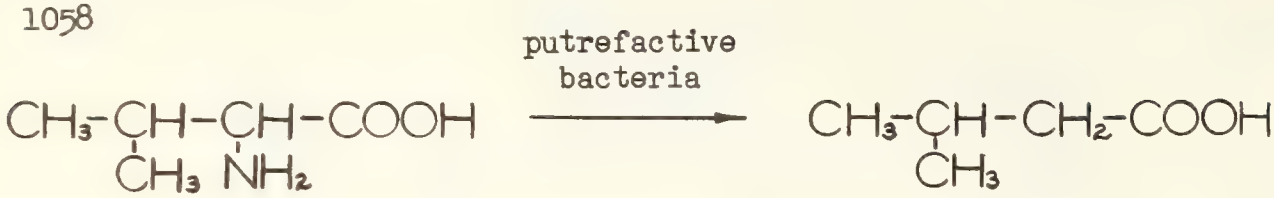


aspartic acid → succinic acid (40-60%)

Neuberg and Karczag, Biochem. Z. 18, 435-9 (1909).

C.A. 3, 2474[2] (1909).

Rx. 1058



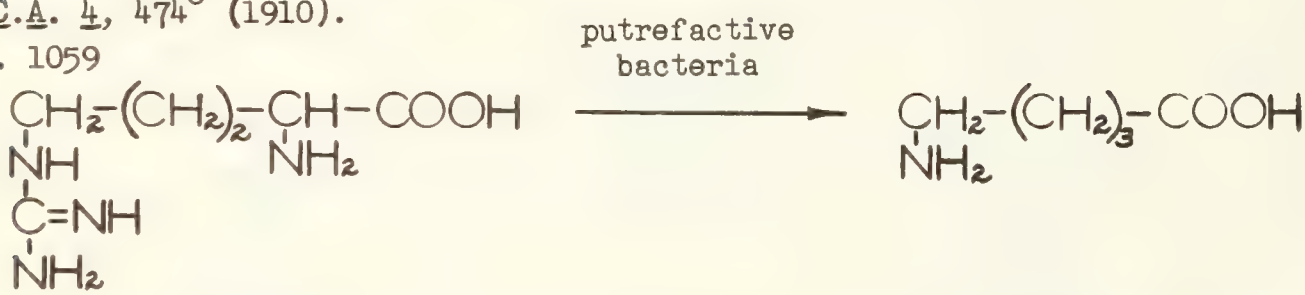
d,l-valine

γ-methyl-n-butyric acid (isovaleric acid)

Ackermann, Z. physiol. Chem. 60, 482-501 (1909).

C.A. 4, 474[8] (1910).

Rx. 1059



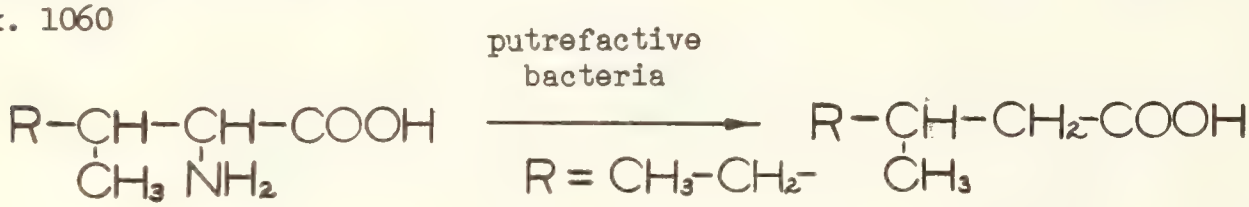
arginine

δ-amino-n-valeric acid

Neuberg, Biochem. Z. 37, 501-6 (1911).

C.A. 6, 500[5] (1912).

Rx. 1060



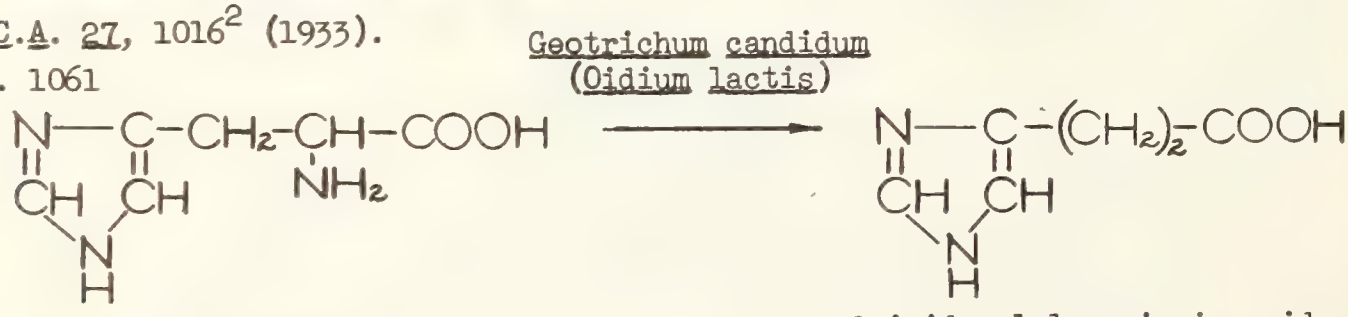
isoleucine

β-methyl-n-valeric acid

Kiyokawa, Z. physiol. Chem. 214, 38-41 (1933).

C.A. 27, 1016[2] (1933).

Rx. 1061

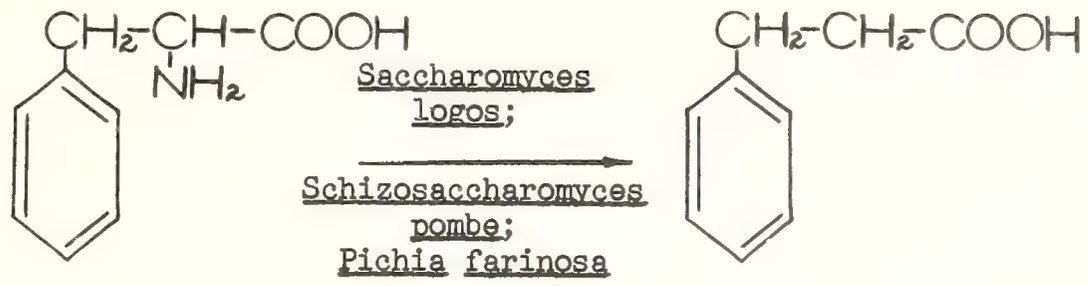


l-histidine

β-imidazolylpropionic acid

Uemura, J. Agr. Chem. Soc. Japan 20, 295-303 (1944).
C.A. 42, 3459i (1948).

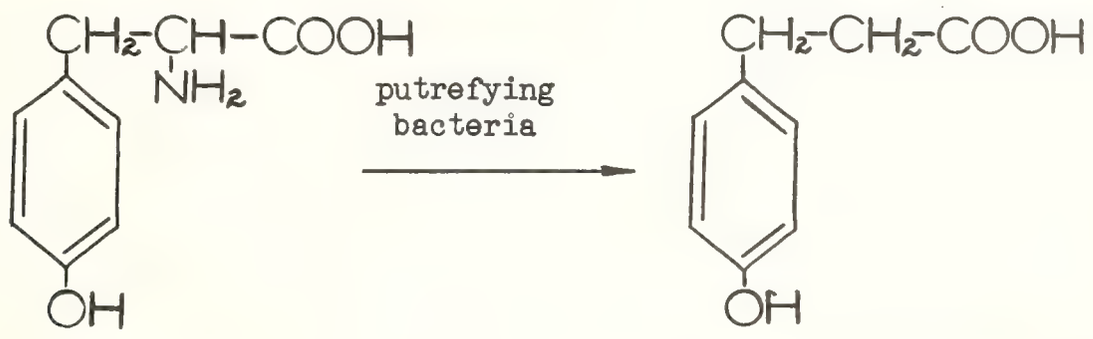
Rx. 1062



L-phenylalanine — β-phenylpropionic acid

Baumann, Ber. 12B, 1450-4 (1879).

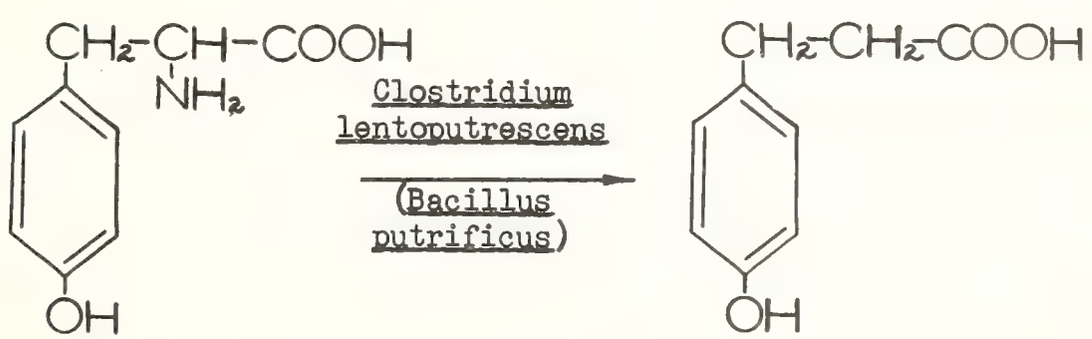
Rx. 1063



tyrosine — β-(p-hydroxyphenyl)-propionic acid

Brasch, Biochem. Z. 22, 403-8 (1909).
C.A. 4, 475[4] (1910).

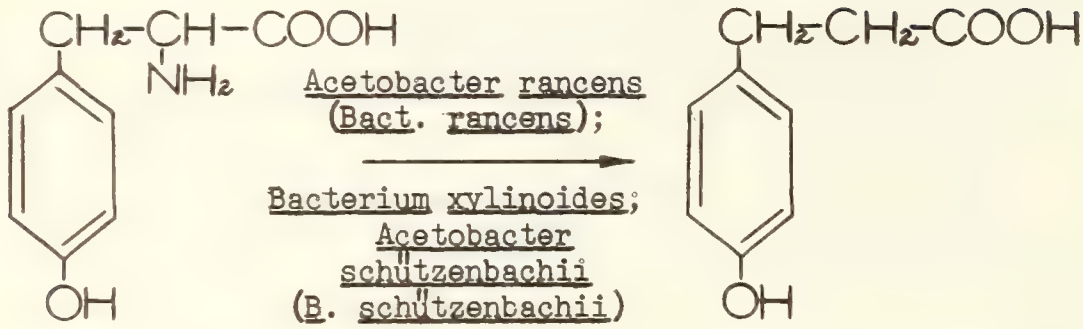
Rx. 1064



tyrosine — β-(p-hydroxyphenyl)-propionic acid

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).
C.A. 20, 2870[9] (1926).

Rx. 1065

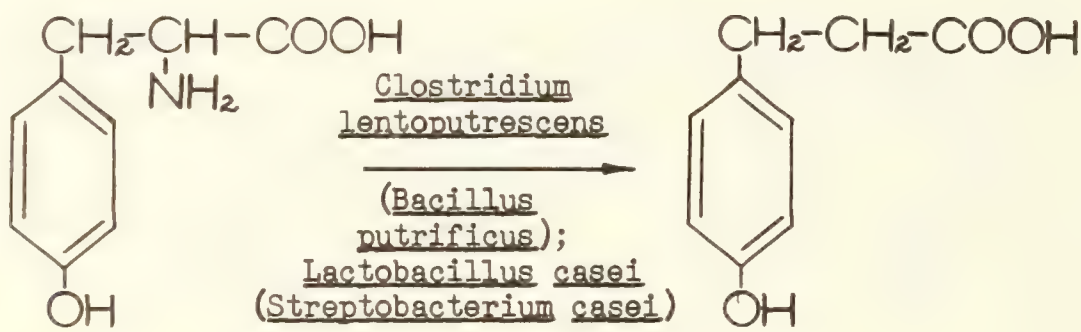


l-tyrosine

l-β-(p-hydroxyphenyl)-propionic acid

Grimmer and Wauschkuhn, Milchw. Forsch. 20, 110-30 (1939).
C.A. 34, 24145 (1940).

Rx. 1066

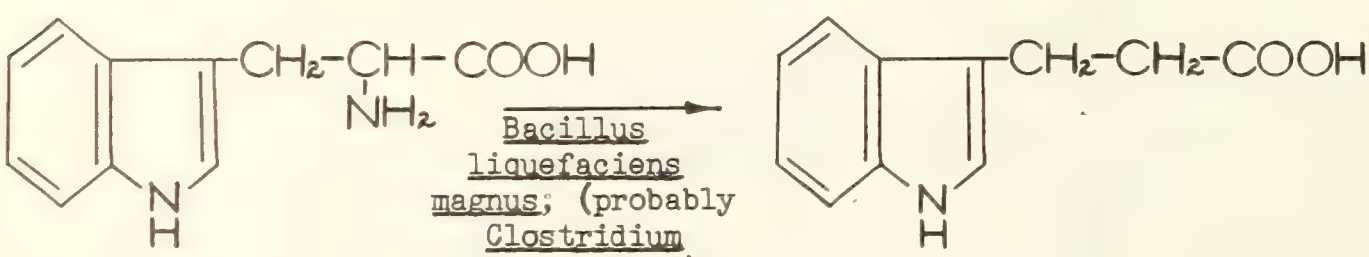


tyrosine

β-(p-hydroxyphenyl)-propionic acid

Nencki, Sitzungsber. K. Akad. Wiss. (Vienna) Math. Naturw. Kl., Abt. IIb, 98, 397-416 (1889). See Nencki, Monatsh. 10, 506-25 (1889).
See Brit. C.A. 58 [i], 78 (1890).

Rx. 1067

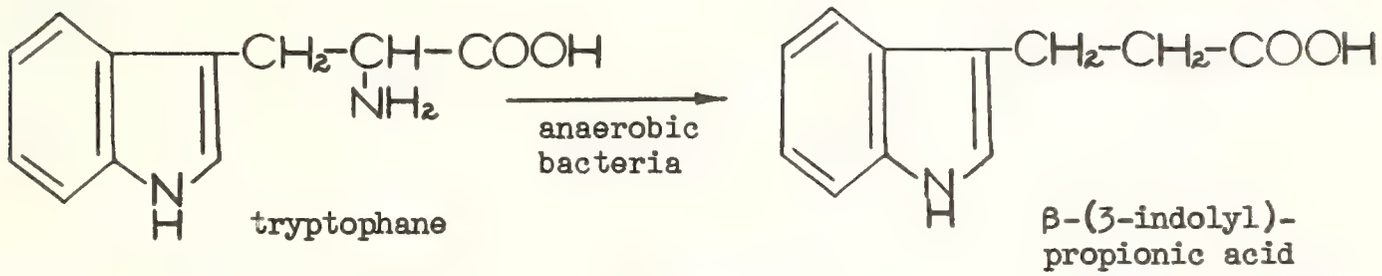


tryptophane

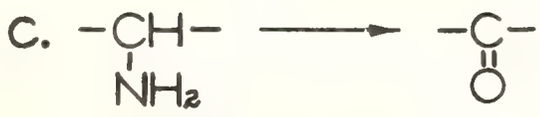
β-(3-indolyl)-propionic acid

Hopkins and Cole, J. Physiol. 29, 451-66 (1903).
Brit. C.A. 84 [i], 590 (1903).

Rx. 1068

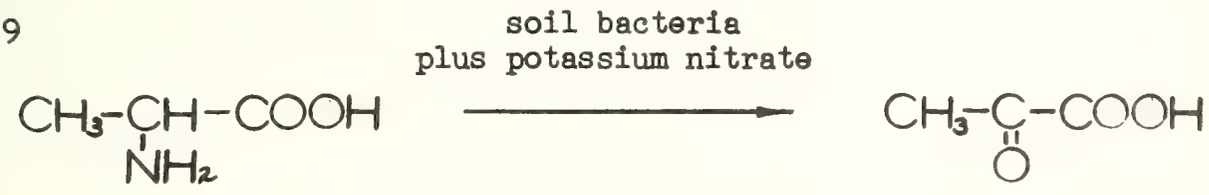


IV. Deamination



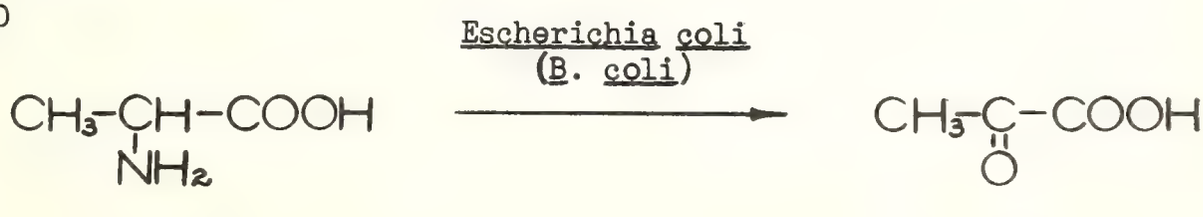
Aubel and Egami, Compt. rend. soc. biol. 119, 1243 (1935).
C.A. 29, 8043[8] (1935).

Rx. 1069



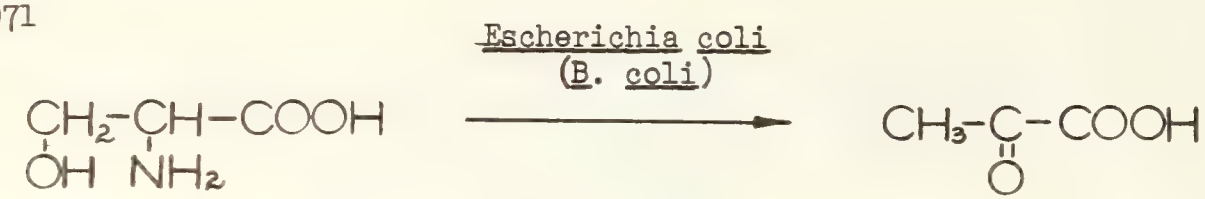
Desnuelle and Grand, Compt. rend. soc. biol. 138, 610-11 (1944).
C.A. 39, 4909[9] (1945).

Rx. 1070



Desnuelle and Grand, Compt. rend. soc. biol. 138, 610-11 (1944).
C.A. 39, 4909[9] (1945).

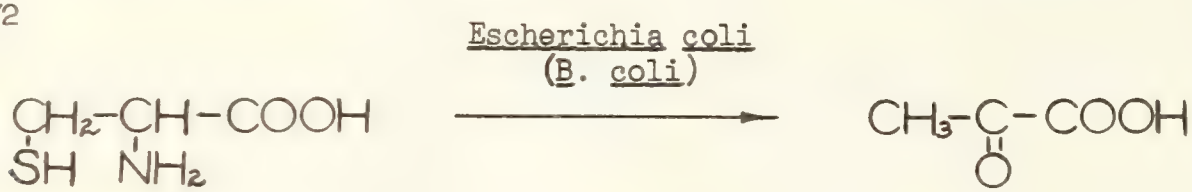
Rx. 1071



serine — pyruvic acid

Desnuelle and Grand, Compt. rend. soc. biol. 138, 610-11 (1944).
C.A. 39, 4909[9] (1945).

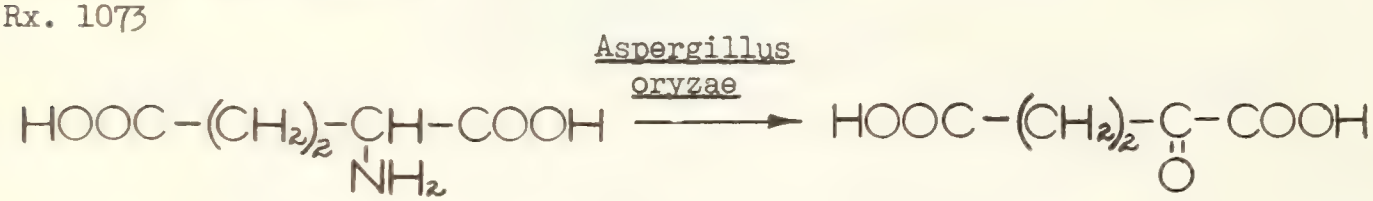
Rx. 1072



cysteine — pyruvic acid

Uemura, J. Agr. Chem. Soc. Japan 15, 353-8 (1939).
C.A. 33, 8671[9] (1939).

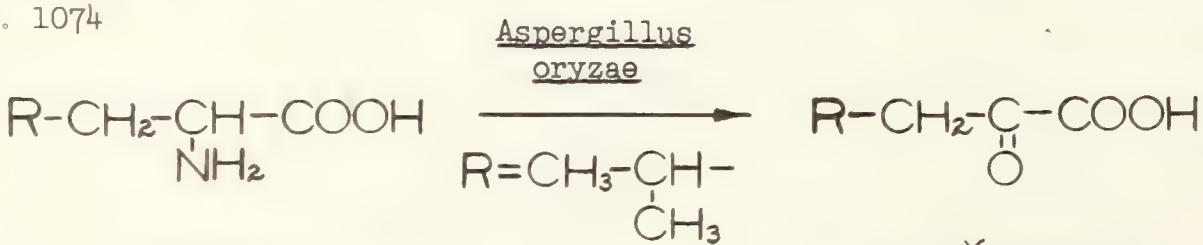
Rx. 1073



glutamic acid — α-ketoglutaric acid

Uemura, J. Agr. Chem. Soc. Japan 15, 353-8 (1939).
C.A. 33, 8671[9] (1939).

Rx. 1074

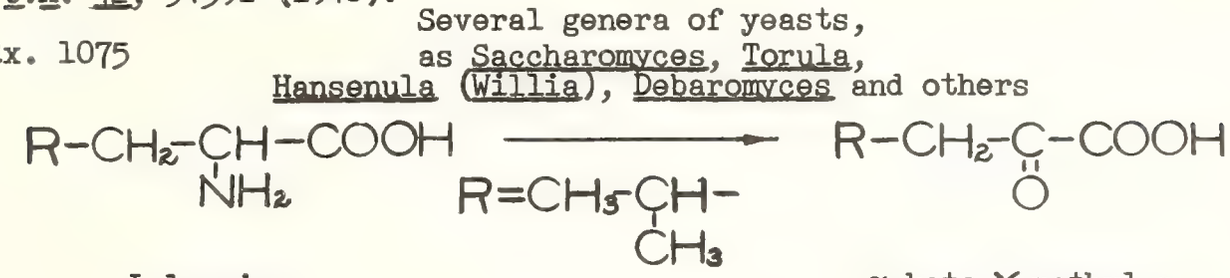


leucine — α-keto-γ-methyl-n-valeric acid

Uemura, J. Agr. Chem. Soc. Japan 20, 295-303 (1944).

C.A. 42, 3459i (1948).

Rx. 1075



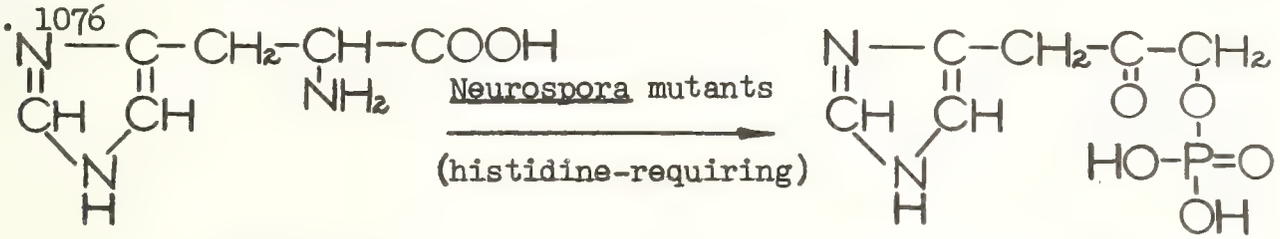
L-leucine

α-keto-γ-methyl-n-valeric acid

Ames and Mitchell, J. Biol. Chem. 212, 687-96 (1955).

C.A. 49, 7057h (1955).

Rx. 1076



histidine

imidazoleacetol phosphate

Neubauer and Fromherz, Z. physiol. Chem. 70, 326-50 (1911).

C.A. 5, 1789[6] (1911).

Rx. 1077

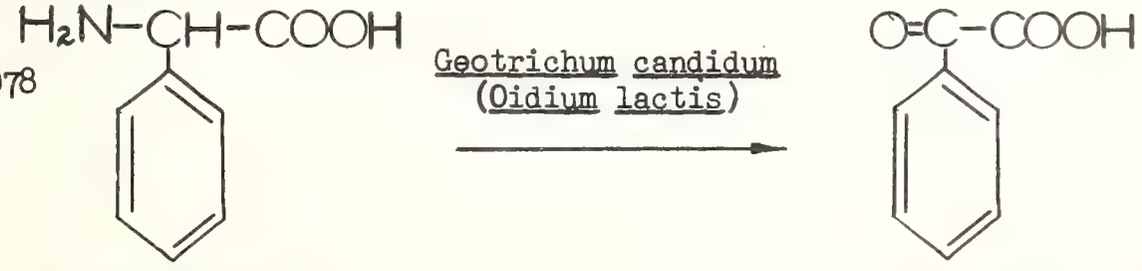
phenylaminoacetic acid (phenylglycine)

phenylglyoxylic acid

Chikano and Kitano, Z. physiol. Chem. 164, 217-25 (1927).

C.A. 21, 1662[1] (1927).

Rx. 1078

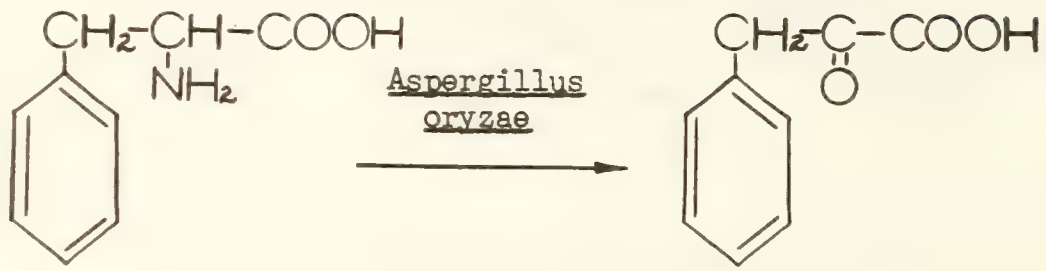


d,l-phenylglycine

phenylglyoxylic acid

Uemura, J. Agr. Chem. Soc. Japan 13, 1146-52 (1937).
C.A. 32, 1739[8] (1938).

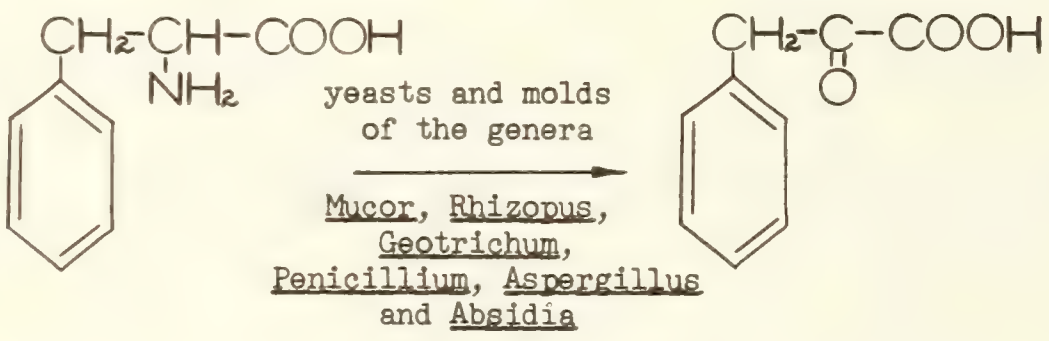
Rx. 1079



l-phenylalanine phenylpyruvic acid

Uemura, J. Agr. Chem. Soc. Japan 20, 231-4 (1944).
C.A. 42, 3459g (1948).

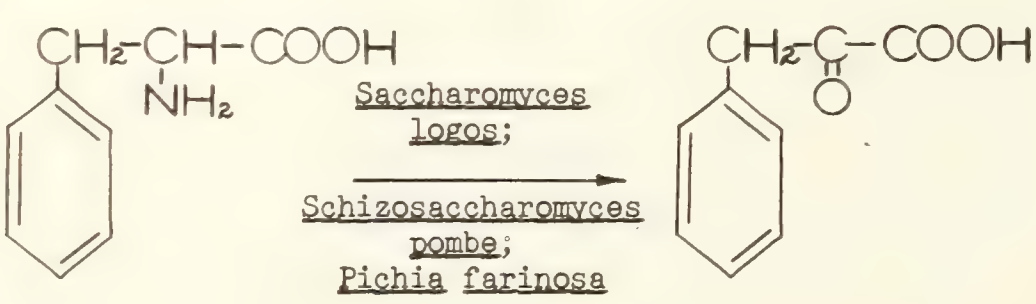
Rx. 1080



L-phenylalanine phenylpyruvic acid

Uemura, J. Agr. Chem. Soc. Japan 20, 295-303 (1944).
C.A. 42, 3459i (1948).

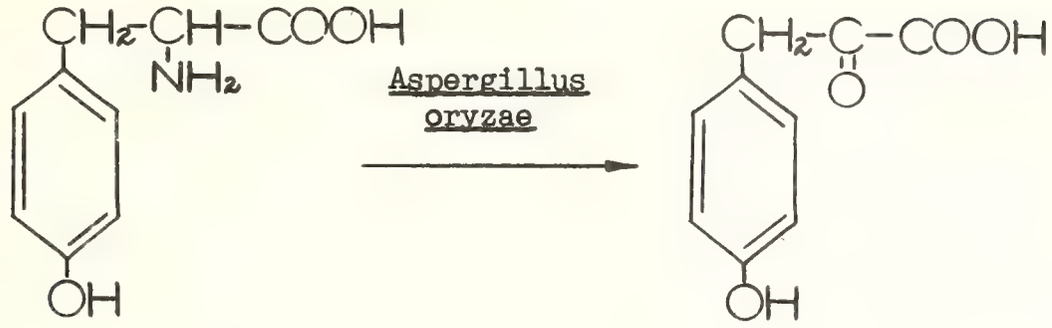
Rx. 1081



L-phenylalanine phenylpyruvic acid

Uemura, J. Agr. Chem. Soc. Japan 15, 353-8 (1939).
C.A. 33, 8671[9] (1939).

Rx. 1082

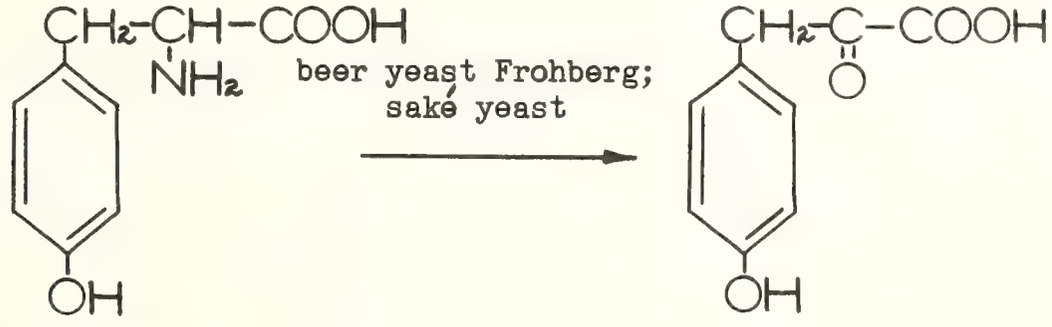


tyrosine

p-hydroxyphenylpyruvic acid

Uemura, J. Agr. Chem. Soc. Japan 20, 295-303 (1944).
C.A. 42, 3459i (1948).

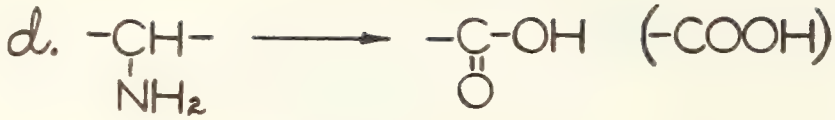
Rx. 1083



L-tyrosine

p-hydroxyphenylpyruvic acid

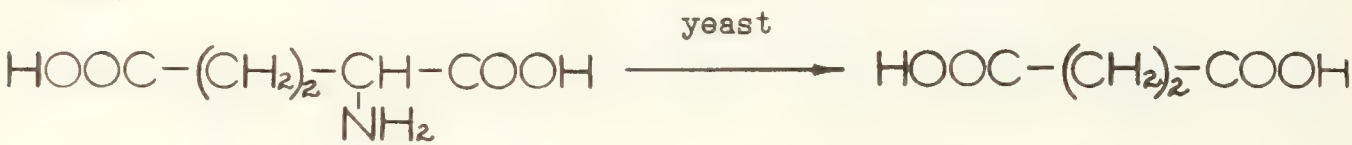
IV. Deamination



Ehrlich, Z. Spiritusind. 30, 327 (1907).

Brit. C.A. 94 [ii], 416 (1908).

Rx. 1084



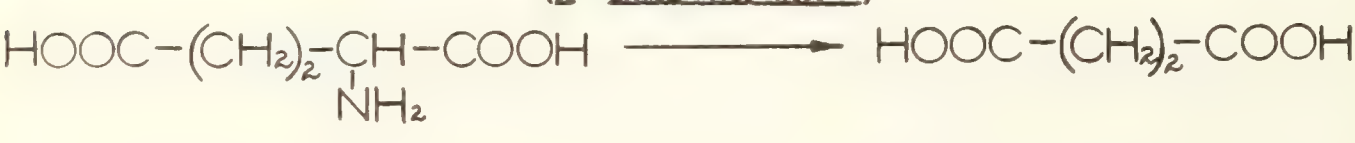
glutamic acid — succinic acid (87%)

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).

C.A. 20, 2870[9] (1926).

Acetobacter aceti (Bact. aceti); A. schützenbachii (B. schützenbachii)

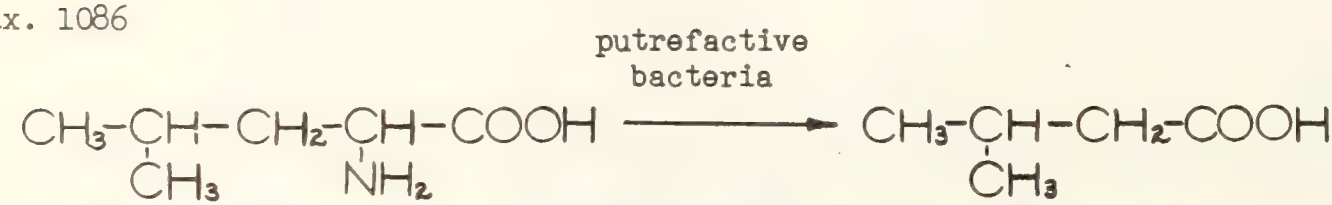
Rx. 1085



d-glutamic acid — succinic acid

Bopp, Ann. 69, 16-37 (1849). (see p. 35).

Rx. 1086

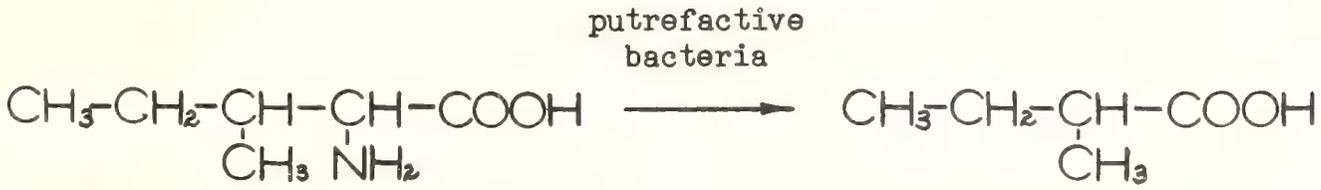


leucine — β-methyl-n-butyric acid

Neuberg, Biochem. Z. 37, 501-6 (1911).

C.A. 6, 5005 (1912).

Rx. 1087



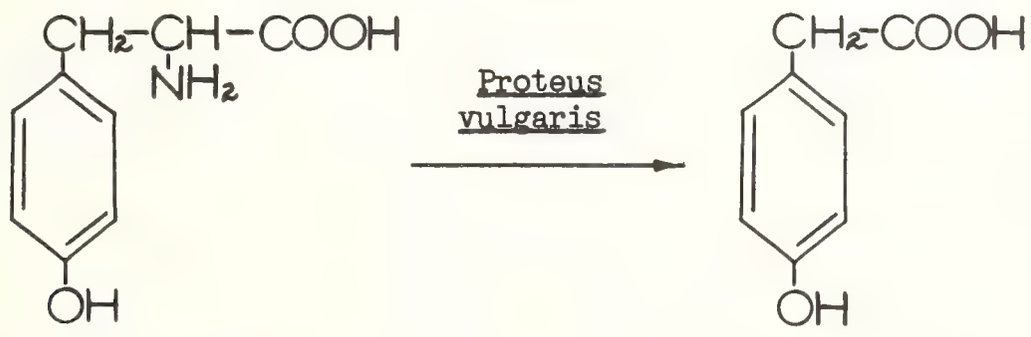
isoleucine

α-methyl-n-butyric acid
(approx. 25%)

Hirai, Biochem. Z. 114, 71-80 (1921).

C.A. 15, 19161 (1921).

Rx. 1088



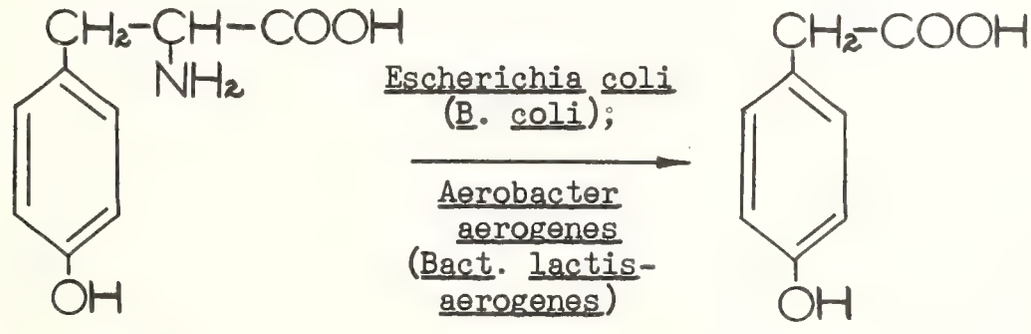
tyrosine

p-hydroxyphenylacetic acid

Grimmer and Wauschkuhn, Milchw. Forsch. 20, 110-30 (1939).

C.A. 34, 24145 (1940).

Rx. 1089



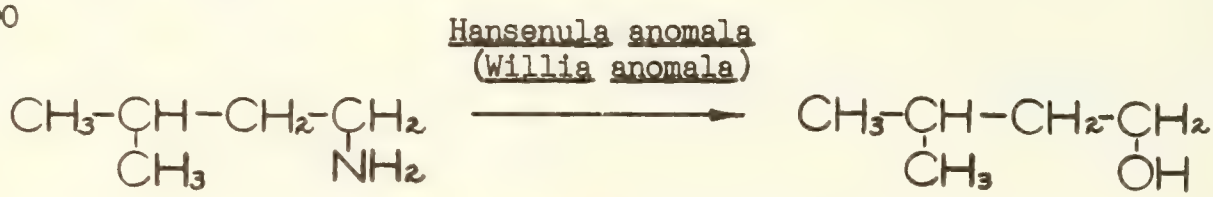
tyrosine

p-hydroxyphenylacetic acid

IV. Deamination

Ehrlich and Pistschimuka, Ber. 45B, 1006-12 (1912).
C.A. 6, 2446[9] (1912).

Rx. 1090

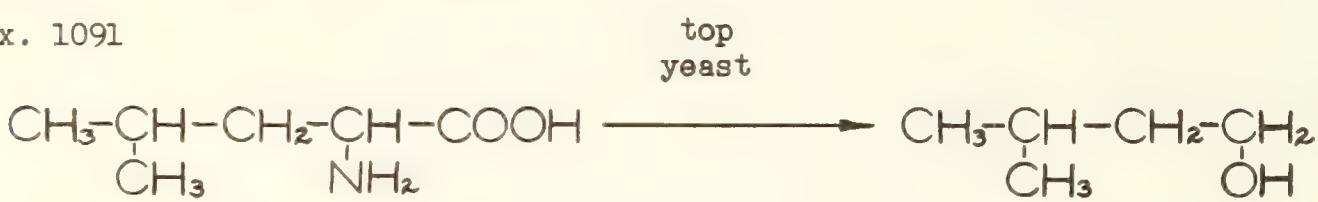


3-methyl-n-butylamine (isoamylamine)

3-methyl-1-butanol (isoamyl alcohol)

Ehrlich, Ber. 40B, 1027-47 (1907).
C.A. 1, 1539[6] (1907).

Rx. 1091

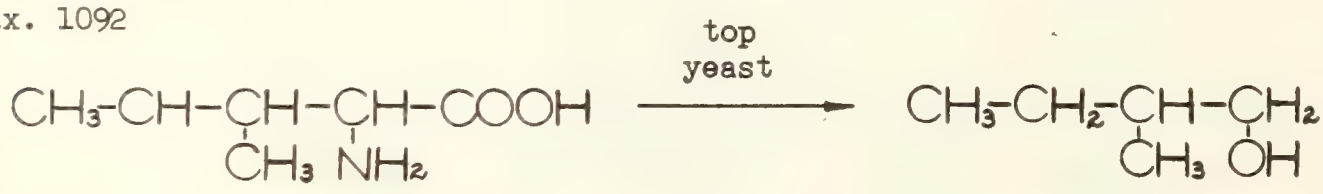


d,l-leucine

3-methyl-1-butanol

Ehrlich, Ber. 40B, 1027-47 (1907).
C.A. 1, 1539[6] (1907).

Rx. 1092

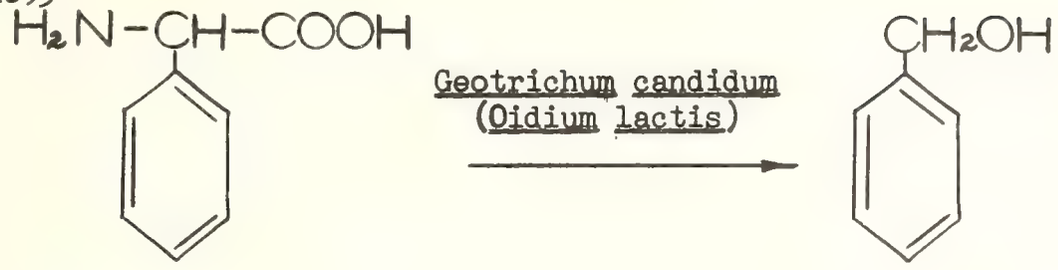


isoleucine

2-methyl-1-butanol

Horsters, Chem. Ztg. 37, 74 (1913).
C.A. 8, 727[1] (1914).

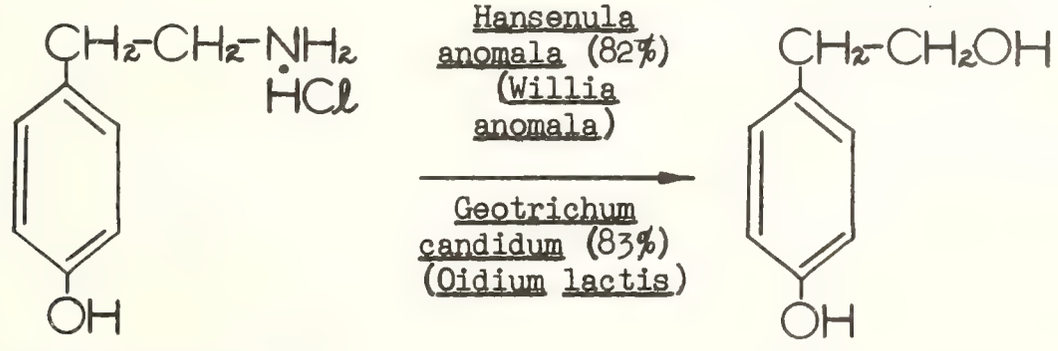
Rx. 1093



phenylglycine — benzyl alcohol (7.8%)

Ehrlich and Pistschimuka, Ber. 45B, 1006-12 (1912).
C.A. 6, 2446[9] (1912).

Rx. 1094



β-(p-hydroxyphenyl)-ethylamine hydrochloride (tyramine hydrochloride)

β-(p-hydroxyphenyl)-ethanol (tyrosol)

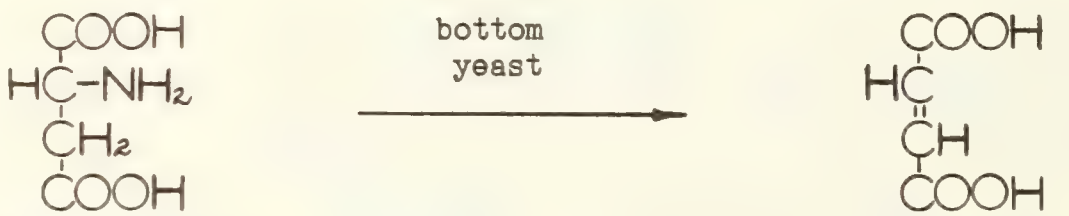
IV. Deamination

f. $-CH_2-\underset{\underset{NH_2}{|}}{CH}- \longrightarrow -CH=CH-$

Leopold, Landw. Jahrb. 85, 534-65 (1938).

C.A. 32, 4612[7] (1938).

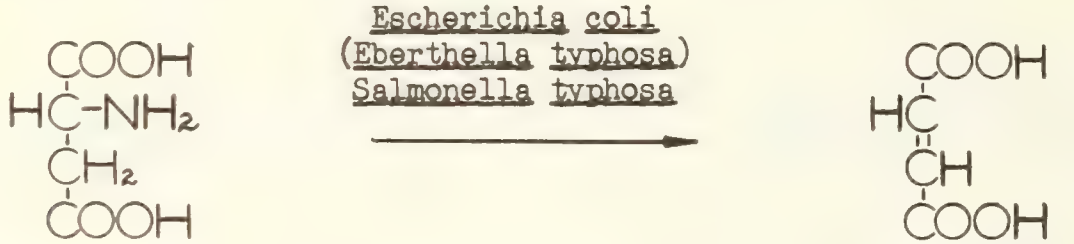
Rx. 1095



aspartic acid — fumaric acid

Bracken, "The Chemistry of Microörganisms." Sir Isaac Pitman and Sons, Ltd. London, 1955. p. 46.

Rx. 1096

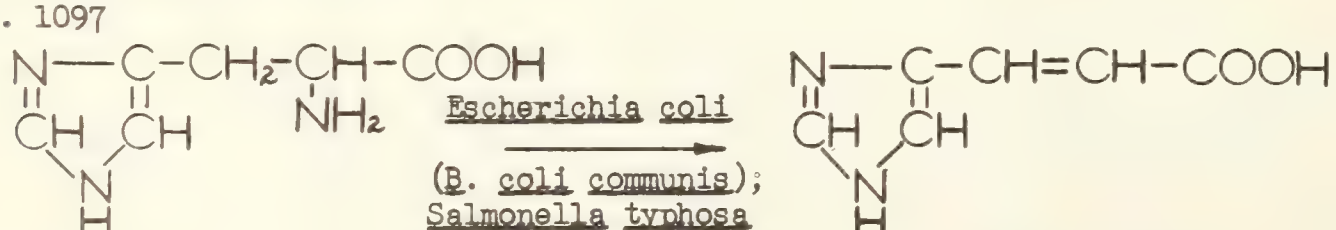


aspartic acid — fumaric acid

Raistrick, Biochem. J. 11, 71-7 (1917).

C.A. 11, 3295[9] (1917).

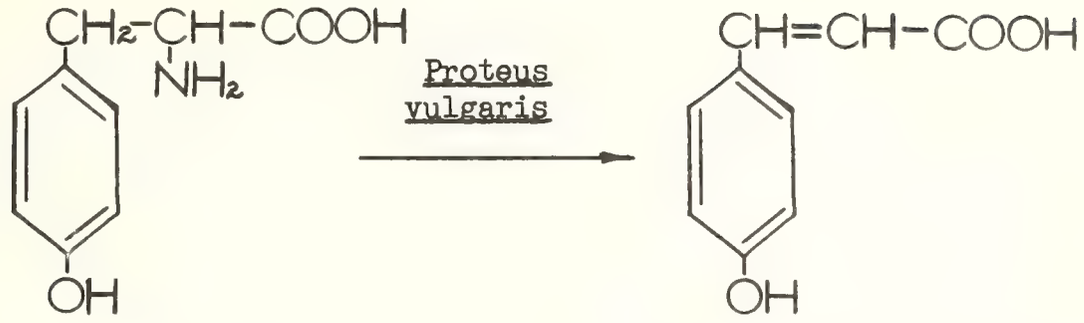
Rx. 1097



histidine — urocanic acid

Hirai, Biochem. Z. 114, 71-80 (1921).
C.A. 15, 1916[1] (1921).

Rx. 1098



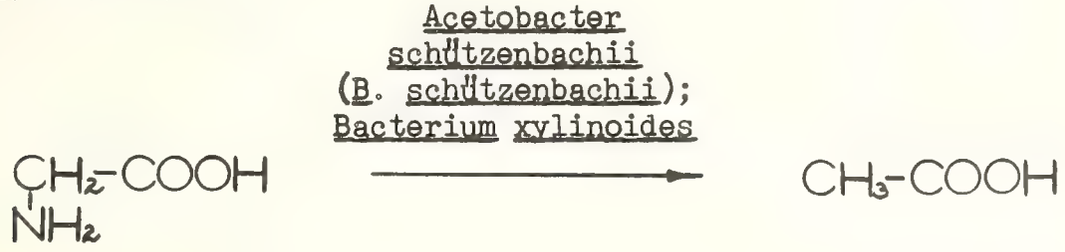
tyrosine — β-(p-hydroxyphenyl)-acrylic acid

IV. Deamination

g. Miscellaneous types

Miyaji, J. Chem. Soc. Japan 45, 391-450 (1925).
C.A. 20, 2870[9] (1926).

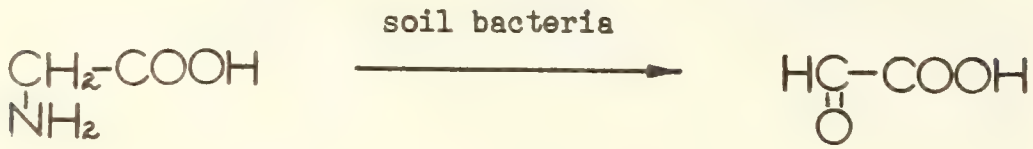
Rx. 1099



glycine (glycocoll) — acetic acid

Egami, Bull. soc. chim. biol. 20, 301-4 (1938).
C.A. 32, 5430[1] (1938).

Rx. 1100

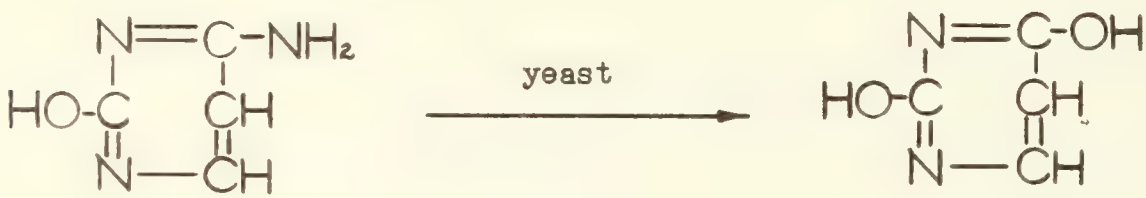


glycine (glycocoll)

glyoxylic acid

Hahn and Lintzel, Z. Biol. 79, 179-90 (1923).
C.A. 18, 1313[9] (1924).

Rx. 1101

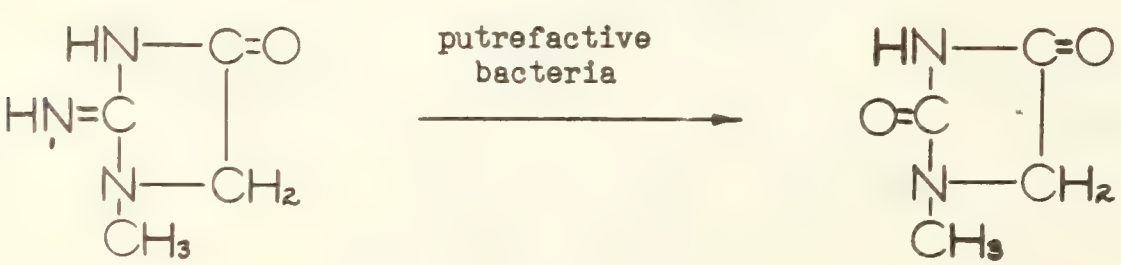


cytosine

uracil

Linneweh, Z. Biol. 90, 109-12 (1930).
C.A. 24, 4061[1] (1930).

Rx. 1102

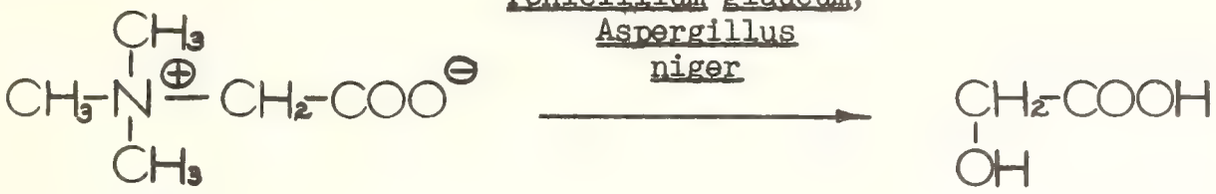


creatinine

methyl hydantoin (approx. 20%)

Ehrlich and Lange, Z. Ver. Zuckerind. 64, 158-71 (1914).
C.A. 8, 2737[5] (1914).

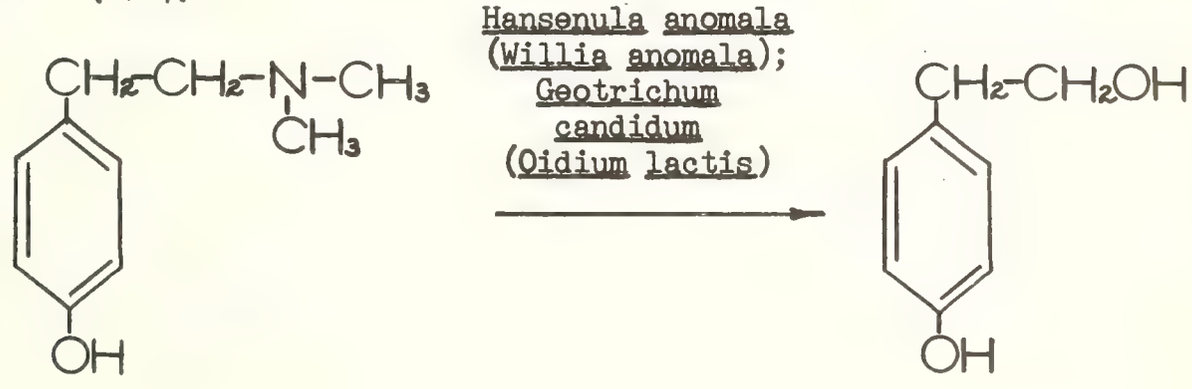
Rx. 1103



betaine — glycolic acid

Ehrlich, Biochem. Z. 75, 417-31 (1916).
C.A. 11, 261[8] (1917).

Rx. 1104



hordenine — tyrosol

V. Glycosylation

Miscellaneous types

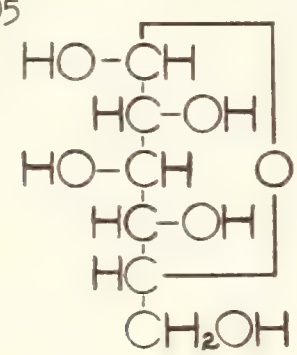
$$n\ R(OH)_2 \longrightarrow -[R-O]-_n$$

$$\underset{OH\ \ OH}{R\text{-}O\text{-}R} + R'(OH)_2 \longrightarrow \underset{OH\ \ OH}{R\text{-}O\text{-}R'} + R(OH)_2$$

$R(OH)_2$ = carbohydrate group

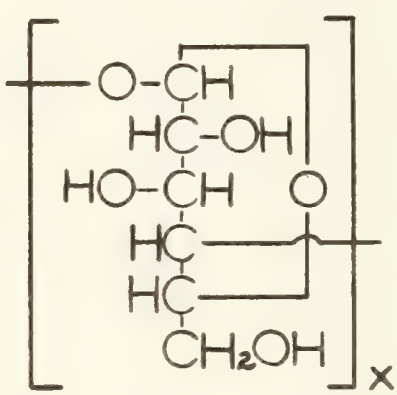
Brown, J. Chem. Soc. 49, 432-9 (1886).

Rx. 1105



D-glucose

Acetobacter xylinum (Bacterium xylinum)

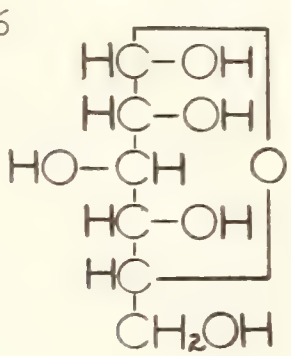


cellulose

Dox and Neidig, J. Biol. Chem. 18, 167-75 (1914).

C.A. 8, 3310[2] (1914).

Rx. 1106



glucose

Penicillium expansum

MYCODEXTRAN

Dox, J. Biol. Chem. 20, 83-5 (1915). See ibid. 19, 235-7 (1914).
C.A. 9, 814[4] (1914).

Rx. 1107

GLUCOSE —(Aspergillus niger)→ MYCODEXTRAN

Raistrick and Rintoul, Trans. Roy. Soc. (London) B220, 225-67 (1931).
C.A. 26, 2486[2] (1932).

Rx. 1108

D-GLUCOSE —(Penicillium luteum)→ LUTEIC ACID (a malonyl-polyglucose)

Birkinshaw and Raistrick, Trans. Roy. Soc. (London) B220, 331-53 (1931).
C.A. 26, 2487[2] (1932).

Rx. 1109

GLUCOSE —(Fumago vagans)→ a polysaccharide containing glucose units only

See Birkinshaw et al., ibid., B220, 355-67 (1931) for use of Penicillium digitatum

---

Murphy et al., Can. J. Biochem. and Physiol. 34, 1271-3 (1956).
C.A. 51, 5205c (1957).

Rx. 1110

GLUCOSE —(Bacillus polymyxa)→ a MANNAN (1%)

See Gorin and Perlin, Can. J. Chem. 34, 1796 (1956) for use of Saccharomyces rouxii

Hida, J. Shanghai Sci. Inst. 1, 85-116 (1934).
C.A. 30, 3855[9] (1936).

Rx. 1111

D-GLUCOSE —(Aspergillus niger: Aspergillus sp.)→ STARCH

Clutterbuck et al., Biochem. J. 28, 94-110 (1934). See Haworth et al., ibid. 29, 612-21; 2668-78 (1935).
C.A. 28, 4100[1] (1934).

Rx. 1112

D-GLUCOSE —(Penicillium charlesii)→ A POLYGALACTOSE (levorotatory)

Albericci et al., Biochem. J. 37, 243-6 (1943).
C.A. 37, 6299[5] (1943).

Rx. 1113

D-GLUCOSE —(Penicillium sclerotiorum)→ SCLEROTIOSE (a polyglucose)

Freeman and Macpherson, Biochem. J. 45, 179-89 (1949).
C.A. 44, 2074e (1950).

Rx. 1114

FRUCTOSE —(Penicillium luteum)→ A POLYGLUCIDE (primarily D-glucose units)

Freeman and Macpherson, Biochem. J. 45, 179-89 (1949).

C.A. 44, 2074e (1950).

Rx. 1115

D-MANNOSE —(Penicillium luteum)→ A POLYGLUCIDE (primarily D-glucose units)

Freeman and Macpherson, Biochem. J. 45, 179-89 (1949).

C.A. 44, 2074e (1950).

Rx. 1116

D-GALACTOSE —(Penicillium luteum)→ A POLYGLUCIDE (primarily polygalactose)

Freeman and Macpherson, Biochem. J. 45, 179-89 (1949).

C.A. 44, 2074e (1950).

Rx. 1117

D-GLUCOSE —(Penicillium luteum)→ A POLYGLUCIDE (primarily D-glucose units)

Godin, Biochim. et Biophys. Acta 12, 528-32 (1953).

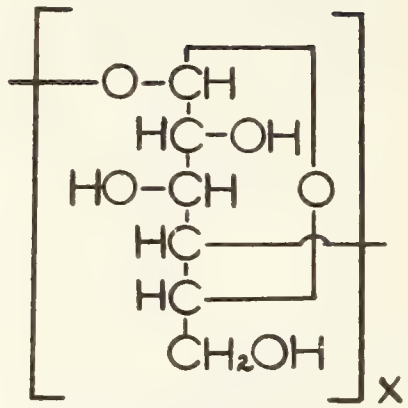
C.A. 48, 4050e (1954).

Rx. 1118

GLUCOSE —(Penicillium brevi-compactum)→ "COMPACTOSE" (a polysaccharide containing only glucose)

Wright and Walker, Chemistry & Industry, 18 (1955).
C.A. 49, 6366e (1955).

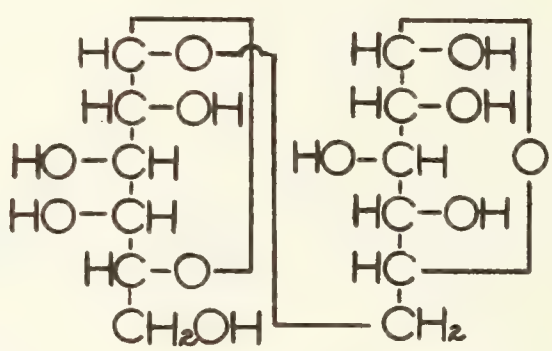
Rx. 1119

GLUCOSE —(Acetobacter acetigenum)→ 

cellulose

Wright and Walker, Chemistry & Industry, 18 (1955)
C.A. 49, 6366e (1955).

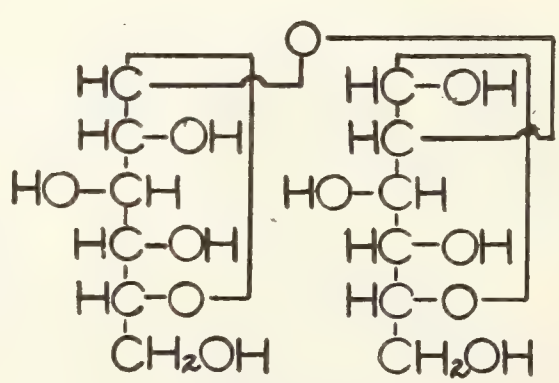
Rx. 1120

GLUCOSE —(Acetobacter acetigenum)→ 

melibiose

Shibasaki, Tohoku J. Agr. Research 6, 171-7 (1955).
C.A. 50, 17494c (1956).

Rx. 1121

GLUCOSE —(Schizosaccharomyces pombe)→ 

kojibiose
(a diglucose, possibly with an α-1,2 -linkage)

Shibasaki, Tohoku J. Agr. Research 6, 171-7 (1955). See ibid. 5, 131-42 (1954); C.A. 50, 5053a (1956).
C.A. 50, 17494c (1956). (See C.A. 50, 11693d)

Rx. 1122

GLUCOSE —Schizosaccharomyces pombe→ SAKÉBIOSE (presumably 3-O-α-D-glucopyranosyl-D-glucopyranose)

Shibasaki, Tohoku J. Agr. Research 6, 171-7 (1955). See ibid. 6, 47-56 (1955).
C.A. 50, 17494c (1956).

Rx. 1123

GLUCOSE —Schizosaccharomyces pombe→ ISOMALTOSE

Barker et al., J. Chem. Soc. 2096-9 (1955).

C.A. 49, 14095e (1955).

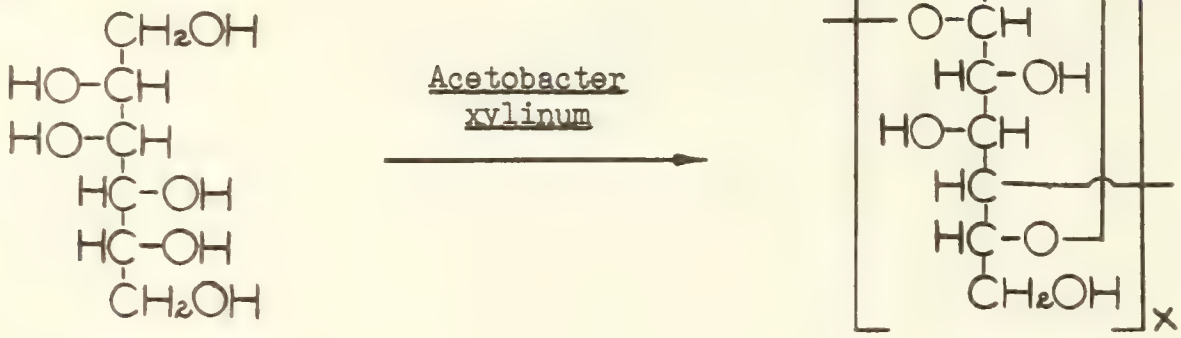
Rx. 1124

GLUCOSE —Leuconostoc mesenteroides (Betacoccus arabinosaceous)→ A DEXTRAN (α-1,6-linkages)

Minor et al., J. Am. Chem. Soc. 76, 5052-4 (1954).

C.A. 49, 1873g (1955).

Rx. 1125



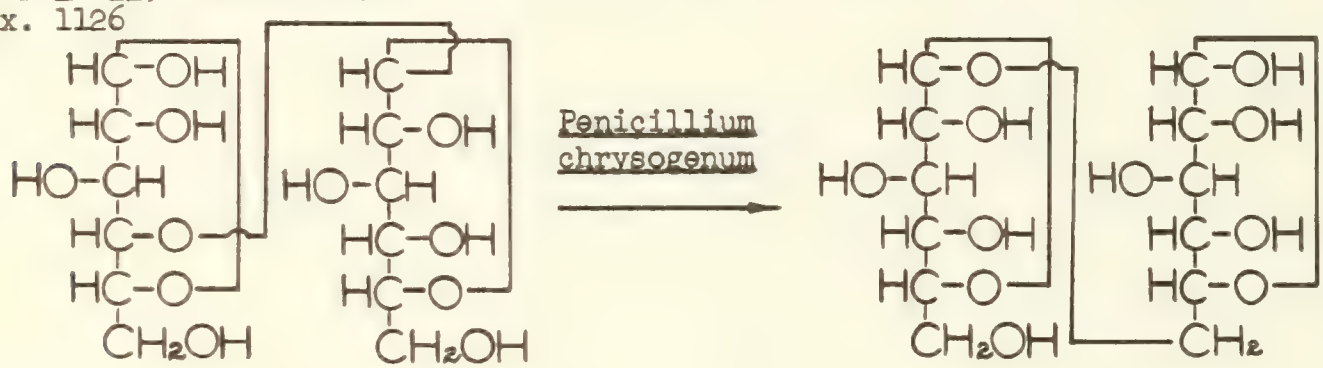
D-mannitol-1-C^{14}

cellulose (C^{14}-labelled at C_1, C_6, C_2, and C_5).

Giri et al., Arch. Biochem. Biophys. 51, 62-7 (1954).

C.A. 48, 10826a (1954).

Rx. 1126



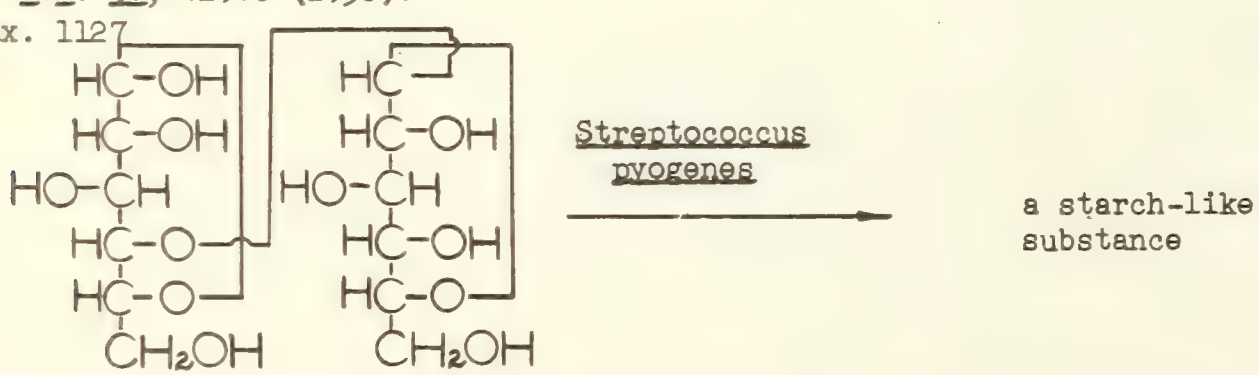
maltose

isomaltose

Crowley and Jevons, J. Gen. Microbiol. 13, 226-34 (1955).

C.A. 50, 4298c (1956).

Rx. 1127



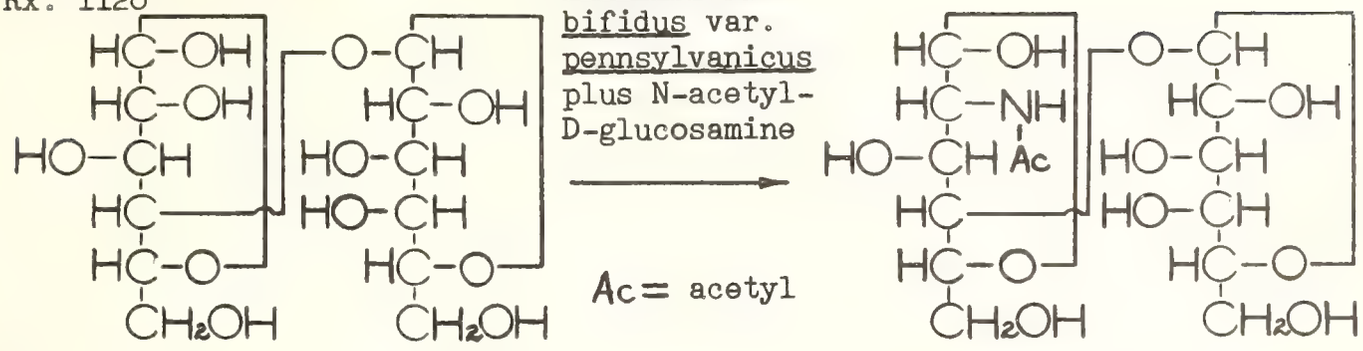
maltose

a starch-like substance

Zilliken et al., J. Biol. Chem. 217, 79-82 (1955).

C.A. 50, 3558i (1956).

Rx. 1128



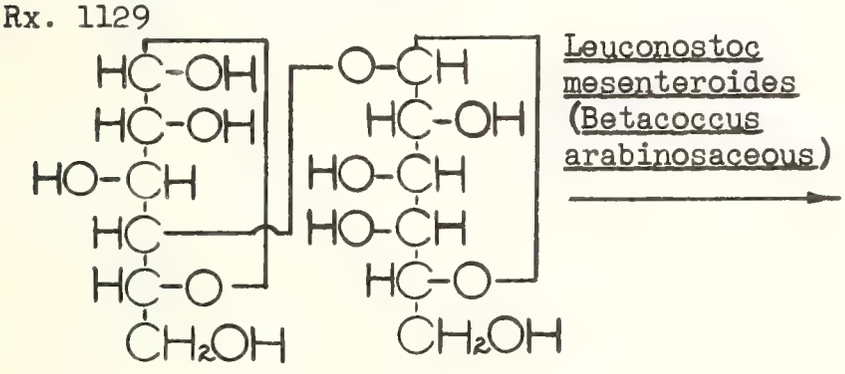
lactose

4-O-β-D-galactopyranosyl-N-acetyl-D-glucosamine (5.4%)

Bailey et al., Nature 176, 1164-5 (1955).

C.A. 50, 6526b (1956).

Rx. 1129



lactose

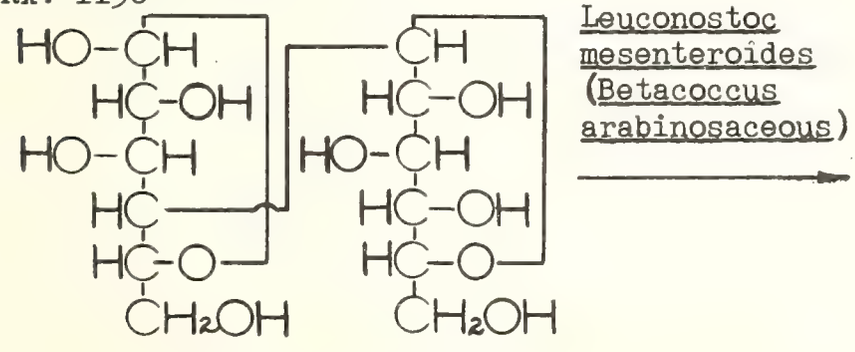
O-β-D-galactopyranosyl-(1⟶4)-O-[α-D-glucopyranosyl-(1⟶2)]-D-glucopyranose

---

Barker et al., Nature 178, 1221-2 (1956).

C.A. 51, 18029a (1957).

Rx. 1130



cellobiose

O-β-D-glucopyranosyl-(1⟶4)-O-[α-D-glucopyranosyl-(1⟶2)]-D-glucopyranose

Dox and Neidig, J. Biol. Chem. 19, 235-7 (1914).
C.A. 8, 3668[1] (1914).

Rx. 1131

SUCROSE —(Aspergillus niger)→ MYCOGALACTAN (hydrolysis gives galactose)

McIntire et al., J. Biol. Chem. 143, 491-6 (1942).
C.A. 36, 4539[6] (1942).

Rx. 1132

SUCROSE —(Agrobacterium tumefaciens (Phytomonas tumefaciens))→ polysaccharide of D-glucose units linked chiefly as β-D-gluco-pyranose rings

---

Carruthers and Cooper, Biochem. J. 30, 1001-9 (1936). See Cooper and Preston, ibid. 29, 2267-77 (1935).
C.A. 30, 6782[8] (1936).

Rx. 1133

SUCROSE —(Bacillus lactis (possibly B. cereus))→ A FRUCTOSAN

Delaporte and Belval, Compt. rend. 222, 1011-13 (1946).
C.A. 40, 5089[1] (1946).

Rx. 1134

SUCROSE —(Phytomonas betae-gelatae n. sp. (Aeromonas?))→ FRUCTOSAN

Yuill, Chemistry & Industry, 755-6 (1952).
C.A. 47, 3398e (1953).
Rx. 1135

SUCROSE —(Aspergillus niger)→ MYCODEXTRAN

Barker et al., J. Chem. Soc., 3084-90 (1953).
C.A. 48, 2815g (1954).
Rx. 1136

SUCROSE —(Aspergillus niger)→ NIGERAN (an essentially unbranched polyglucosan)

Smith, Proc. Linnean Soc. N. S. Wales 26, 589-625 (1901). See Adv. Carbohyd. Chem. 2, 226 (1946).
See Can. J. Research 3, 463 (1930) for other refs. to Smith
Rx. 1137

SUCROSE —(Bacillus levaniformans (probably a variety of B. vulgatus))→ LEVAN

Smith, J. Soc. Chem. Ind. 23, 972-5 (1904).

Rx. 1138

SUCROSE —(Bacterium eucalypti "Nomen nudem")→ LEVAN

Harrison et al., Can. J. Research 3, 449-63 (1930).
C.A. 25, 723[4] (1931).

Rx. 1139

SUCROSE —(Bacillus subtilis; B. mesentericus Trevisan (same as B. subtilis Cohn))→ LEVAN (54%)

Niven et al., J. Biol. Chem. 140, 105-9 (1941).
C.A. 35, 6617[8] (1941).

Rx. 1140

SUCROSE —(Streptococcus salivarius)→ A LEVAN

Hestrin et al., Biochem. J. 37, 450-6 (1943).
C.A. 38, 984[3] (1944).

Rx. 1141

SUCROSE —(Bacillus polymyxa; Aerobacter levanicum; B. subtilis)→ LEVAN

Erikson, Ann. Applied Biol. 32, 44-52 (1945). See Gilbert and Stacey, J. Chem. Soc., 1560-1 (1948).

C.A. 39, 5288[1] (1945).

Rx. 1142

SUCROSE —(Pseudomonas mors-prunorum; Ps. syringae (Ps. prunicola); other Pseudomonas sp.)→ A LEVAN

Murphy, Can. J. Chem. 30, 872-8 (1952).

C.A. 47, 10619g (1953).

Rx. 1143

SUCROSE —(Bacillus polymyxa)→ A LEVAN

Feingold, Bull. Res. Council Israel 5A, 94 (1955). See J. Polymer Sci. 23, 783-90 (1957). C.A. 51, 1797a.

C.A. reference not available

Rx. 1144

SUCROSE —(Aerobacter levanicum)→ A LEVAN

Fuchs, Nature 178, 921 (1956).

C.A. 51, 3742d (1957).

Rx. 1145

SUCROSE —(Pseudomonas fluorescens (49%); Ps. chlororaphis; Ps. aureofaciens (83%))→ A LEVAN

Bauer, Biedermanns Zentr., 630 (1882).

Brit. C.A. 44 [i], 105 (1883).

Rx. 1146

SUCROSE (molasses) —microorganisms→ DEXTRAN

Boekhout, Zent. Bakt. Parasitenk. [ii] 6, 161-5 (1900).

Brit. C.A. 78 [ii], 742 (1900).

Rx. 1147

SUCROSE —A new species of Streptococcus, named by author S. hornensis (probably of the Leuconostoc sp.)→ A DEXTRAN

Tarr and Hibbert, Can. J. Research 5, 414-27 (1931). (See Barker et al., J. Chem. Soc., 2395-9 (1954).
C.A. 26, 6989 (1932).

Rx. 1148

SUCROSE —Leuconostoc mesenteroides→ a dextran of unknown structure

---

Carruthers and Cooper, Biochem. J. 30, 1001-9 (1936). See Peat et al., J. Chem. Soc., 581-5 (1939).
C.A. 30, 67828 (1936).

Rx. 1149

SUCROSE —Leuconostoc dextranicum→ A DEXTRAN (25%)

Daker and Stacey, Biochem. J. 32, 1946-8 (1938). See J. Chem. Soc., 585-7 (1939).
C.A. 33, 3420[3] (1939).

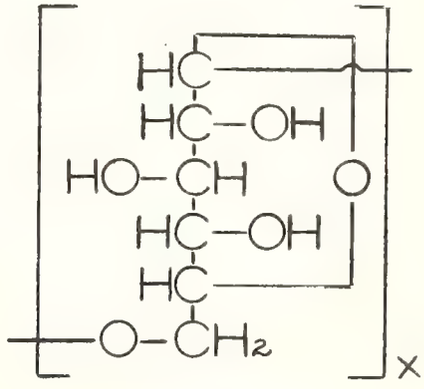
Rx. 1150

SUCROSE —(Lactobacillus brevis (Betabacterium vermiformе))→ A DEXTRAN

Niven et al., J. Biol. Chem. 140, 105-9 (1941).
C.A. 35, 6617[8] (1941).

Rx. 1151

SUCROSE —(Streptococcus bovis)→



a dextran

Barker et al., Chemistry & Industry, 1450-1 (1955).
C.A. 50, 14173i (1956).

Rx. 1152

SUCROSE —(a streptococcus)→ A DEXTRAN (α-1,6-linkages)

Hehre, J. Biol. Chem. 222, 739-50 (1956).

C.A. 51, 2121f (1957).

Rx. 1153

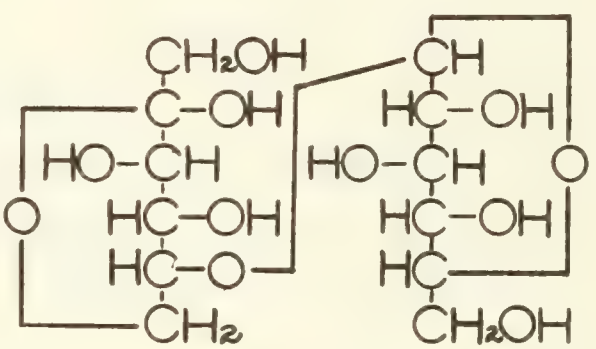
SUCROSE —(a non-hemolytic streptococcus)→ DEXTRAN (41%) (low mol. wt.)

Stodola et al., J. Am. Chem. Soc. 74, 3203-3 (1952).

C.A. 48, 2608i (1954).

Rx. 1154

SUCROSE —(Leuconostoc mesenteroides)→



leucrose
(3% of sucrose utilized)

Morooka, Japan. J. Med. Sci. and Biol. 7, 1-13 (1954).

C.A. 48, 10829e (1954).

Rx. 1155

SUCROSE —(Escherichia coli (Escherichia coli var. communior))→ A TRISACCHARIDE (possibly glucose-glucose-fructose)

Bailey et al., Nature 175, 635 (1955).

C.A. 49, 13363b (1955).

Rx. 1156

SUCROSE (+ 20% glucose) —Leuconostoc mesenteroides→ ISOMALTOSE

Bailey et al., Nature 175, 635 (1955).

C.A. 49, 13363b (1955).

Rx. 1157

SUCROSE (+ 20% glucose) —Leuconostoc mesenteroides→ ISOMALTOTRIOSE

Russi and Ballio, Boll. soc. ital. biol. sper. 31, 1362-3 (1955).

C.A. 50, 10855d (1956).

Rx. 1158

SUCROSE —Penicillium chrysogenum→ O-α-D-glucopyranosyl-(1⟶2)-O-β-D-fructofuranosyl-(1⟶2)-β-D-fructofuranoside

---

Smith, J. Soc. Chem. Ind. 23, 972-5 (1904).

Rx. 1159

RAFFINOSE —Bacterium eucalypti "Nomen nudem"→ LEVAN

Harrison et al., Can. J. Research 3, 449-63 (1930).

C.A. 25, 723[4] (1931).

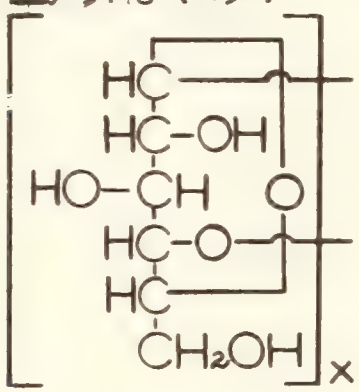
Rx. 1160

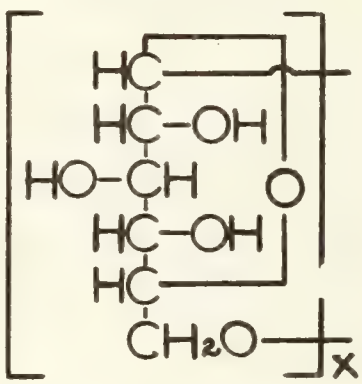
RAFFINOSE —(Bacillus subtilis; B. mesentericus Trevisan (the same as B. subtilis Cohn))→ A LEVAN

Hehre, J. Biol. Chem. 192, 161-74 (1951).

C.A. 46, 578g (1952).

Rx. 1161



dextrin —(Acetobacter capsulatum)→ 

dextran (22%)

Kooi, U.S. 2,689,816 (Sept. 21, 1954).

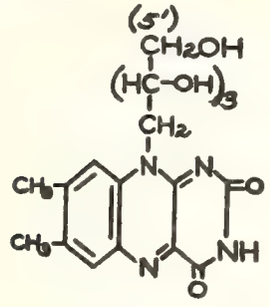
C.A. 49, 2672c (1955).

Rx. 1162

PARTIALLY HYDROLYZED STARCH —(Acetobacter capsulatum; A. viscosum)→ DEXTRAN (38-42%)

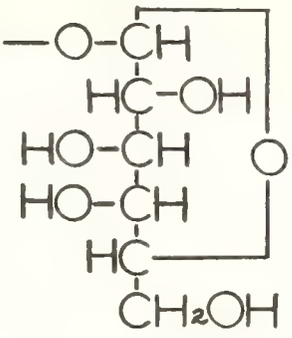
Tachibana, Vitamins (Japan) 9, 119-24 (1955). See ibid. 8, 304-8 (1955). C.A. 50, 15701a (1956).

Rx. 1163



riboflavin

Aspergillus oryzae
mutant plus lactose



β-(5'-D-riboflavinyl)-D-galactoside

VI. Hydrolysis

Schardinger, Wien. klin. Wochenschr. 17, 207-9 (1904).

Rx. 1164

STARCH —(Bacillus macerans)→ DEXTRIN

Schardinger, Zentr. Bakt. Parasitenk. Abt. II 22, 98-103 (1908).
C.A. 3, 910[3] (1909).

Rx. 1165

STARCH —(Bacillus macerans)→ NON-REDUCING POLYSACCHARIDES (5%)

Peterson et al., Biochem. Z. 219, 1-6 (1930).
C.A. 24, 3030[9] (1930).

Rx. 1166

STARCH —(Clostridium butyricum (Bacillus amylobacter Bredemann); Clostridium acetobutylicum (B. saccharobutyricus liquefaciens))→ α-D-GLUCOSE

Peterson et al., Biochem. Z. 219, 1-6 (1930).
C.A. 24, 3030[9] (1930).

Rx. 1167

CELLULOSE —(a bacterial culture from horse manure)→ β-D-GLUCOSE

Iwata, Bull. Imp. Coll. Agr. and Forestry Morioka (Japan) No. 21, 120 pp. (1935).
C.A. 30, 7178[1] (1936).

Rx. 1168

XYLAN —(microörganisms from alimentary tract of animals)→ XYLOSE

Sørensen, Nature 177, 845 (1956).

C.A. 51, 554h (1957).

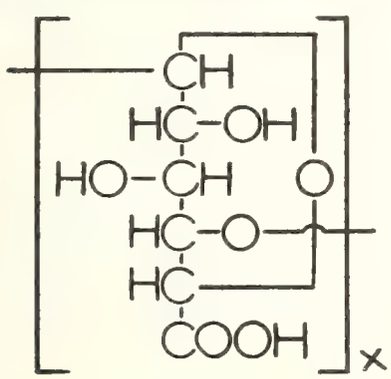
Rx. 1169

XYLAN —(Sporocytophaga myxococcoides)→ XYLOSE, XYLOBIOSE, AND XYLOTRIOSE

Loicjanskaja, Compt. rend. acad. sci. U.R.S.S. 14, 381-4 (1937).

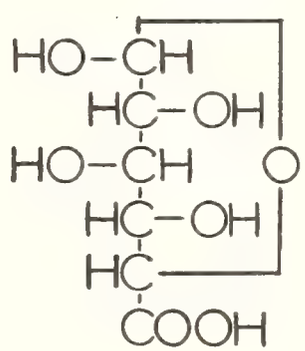
C.A. 31, 6279[8] (1937).

Rx. 1170



polyglucuronic acid
(from cellulose oxidation)

—(Sporocytophaga myxococcoides (Spirocheta cytophaga))→

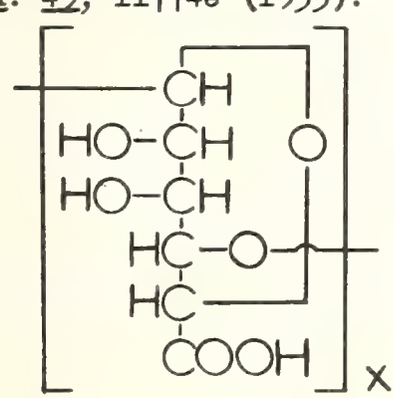


glucuronic acid

Yoshikawa, Science Repts. Hyogo Univ. Agr., Ser. Agr. Chem. 1, 53-5 (1954).

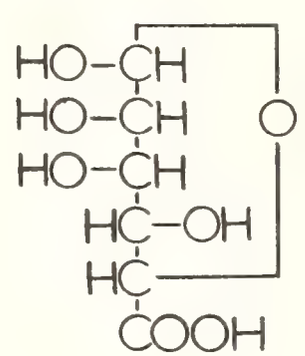
C.A. 49, 11774e (1955).

Rx. 1171



alginic acid
(Na salt)

—(Pseudomonas alginoliquefaciens (Alginomonas sp.?))→

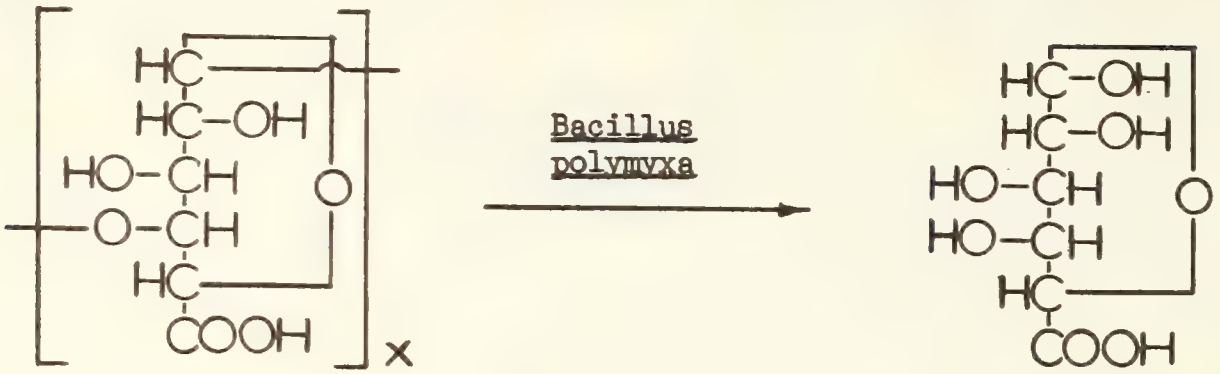


mannuronic acid

Potter and McCoy, J. Bacteriol. 70, 656-62 (1955).

C.A. 50, 3551i (1956).

Rx. 1172



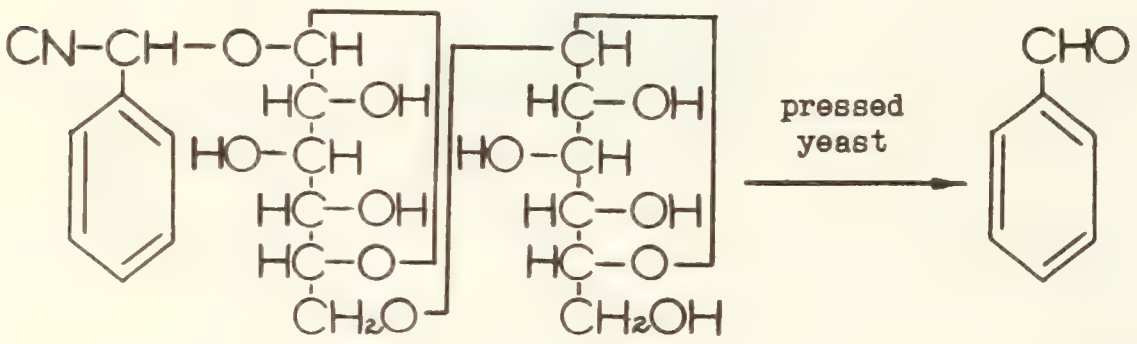
pectic acid

galacturonic acid

Henry and Auld, Proc. Roy. Soc. 76B, 568-80 (1905).

Brit. C.A. 90 [ii], 114 (1906).

Rx. 1173



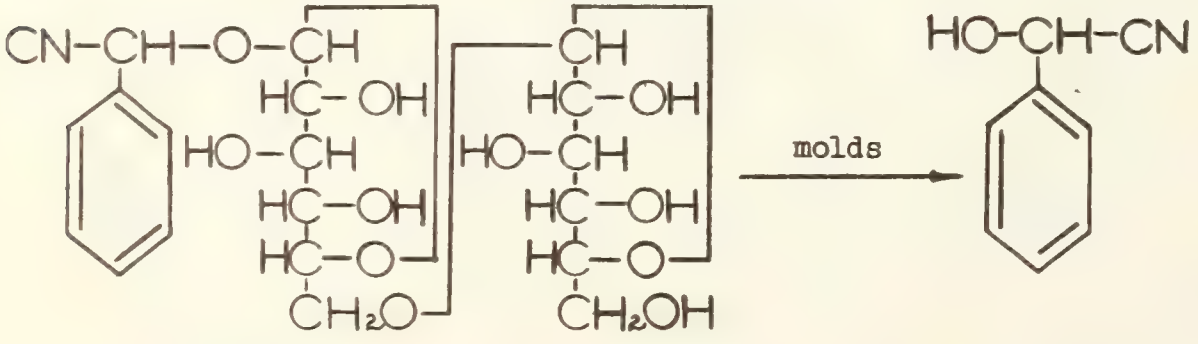
amygdalin

benzaldehyde
(plus HCN and glucose)

Uhlenhaut, Ann. mycol. 9, 567-621 (1911).

C.A. 6, 2249[4] (1912).

Rx. 1174



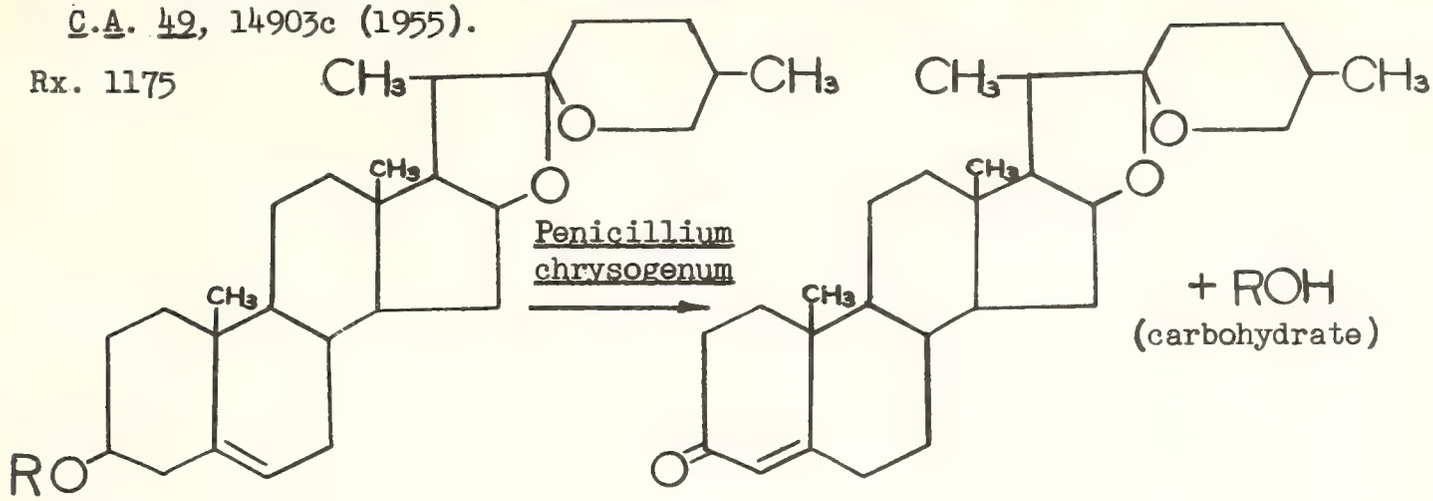
amygdalin

benzalcyanohydrin
(plus glucose)

Rothrock et al., Arch. Biochem. Biophys. 57, 151-5 (1955).

C.A. 49, 14903c (1955).

Rx. 1175



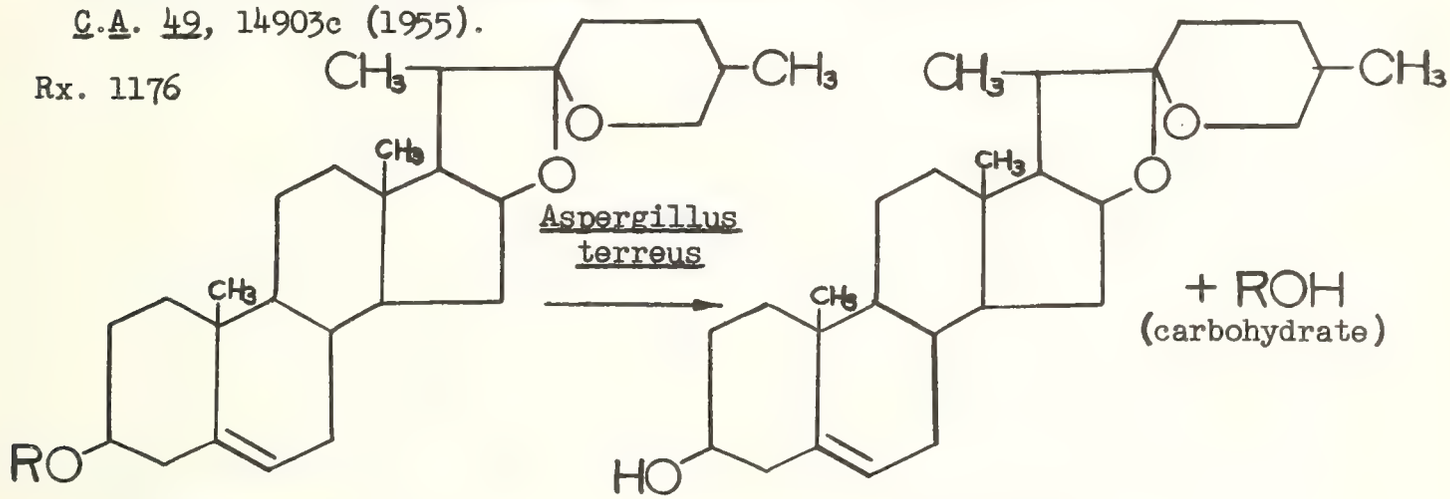
saponins

Δ^4-diosgenone (3.6%)

Rothrock et al., Arch. Biochem. Biophys. 57, 151-5 (1955).

C.A. 49, 14903c (1955).

Rx. 1176



saponins

diosgenin
(90-100% of acid hydrolysis value)

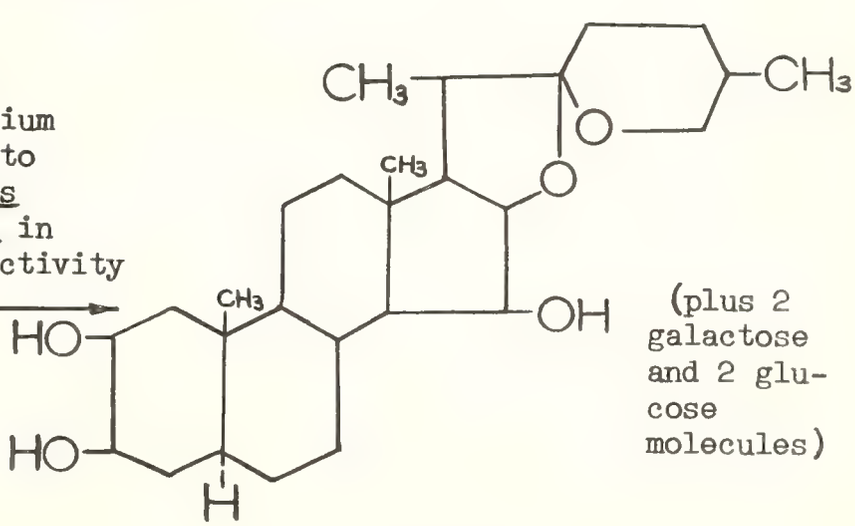
Schiesser, Ricerca sci. 22, 449-60 (1952).

C.A. 49, 4085d (1955).

Rx. 1177

DIGITONIN
($C_{55}H_{90}O_{29}$)

a bacterium similar to Bacillus macerans in hydrolytic activity



(plus 2 galactose and 2 glucose molecules)

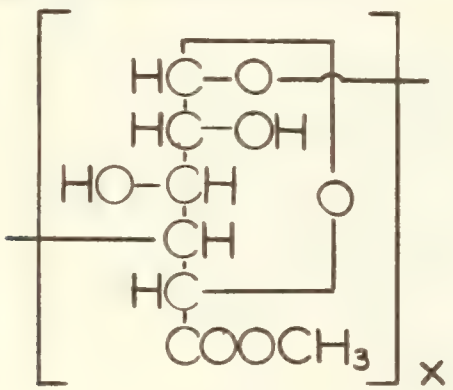
digitogenin
(suggested structure)

VI. Hydrolysis

b. $R-COOR' + H_2O \longrightarrow R'OH + R-COOH$

Kraght and Starr, Arch. Biochem. Biophys. 42, 271-7 (1953).
C.A. 47, 8829h (1953).

Rx. 1178



pectin

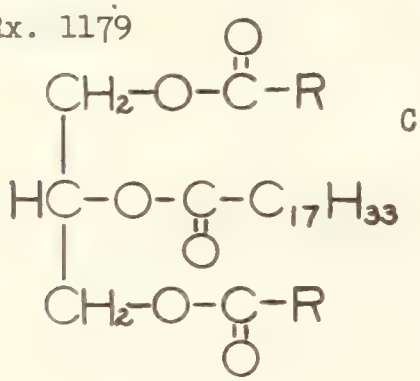
Erwinia carotovora

CH_3OH

methanol (nearly 100%)

Pigulewski and Charik, Biochem. Z. 200, 201-10 (1928).
C.A. 23, 629^9 (1929).

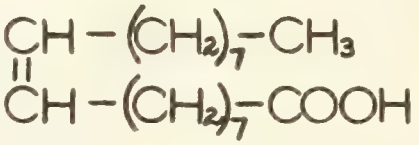
Rx. 1179



olive oil

microorganisms

$C_{17}H_{33}$ = $\Delta^{8,9}$-heptadecenyl

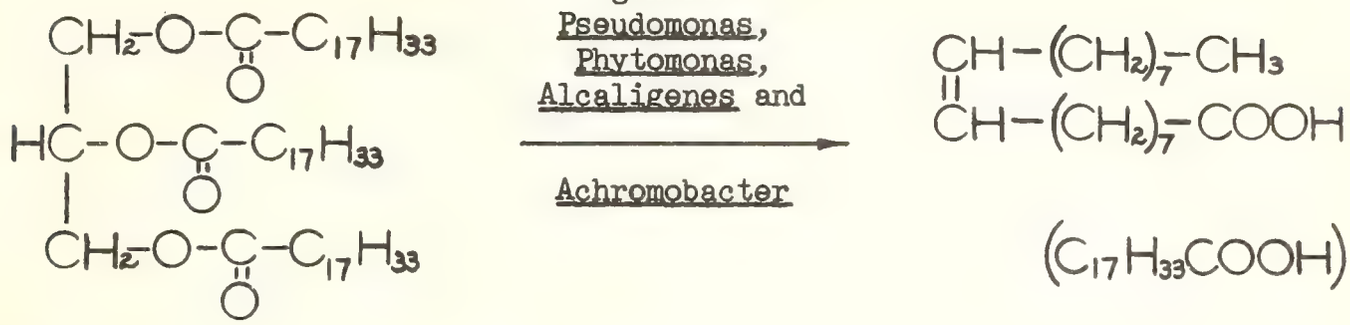


oleic acid

Castell and Garrard, Can. J. Research 19C 106-10 (1941).

C.A. 35, 3839[5] (1941).

Rx. 1180



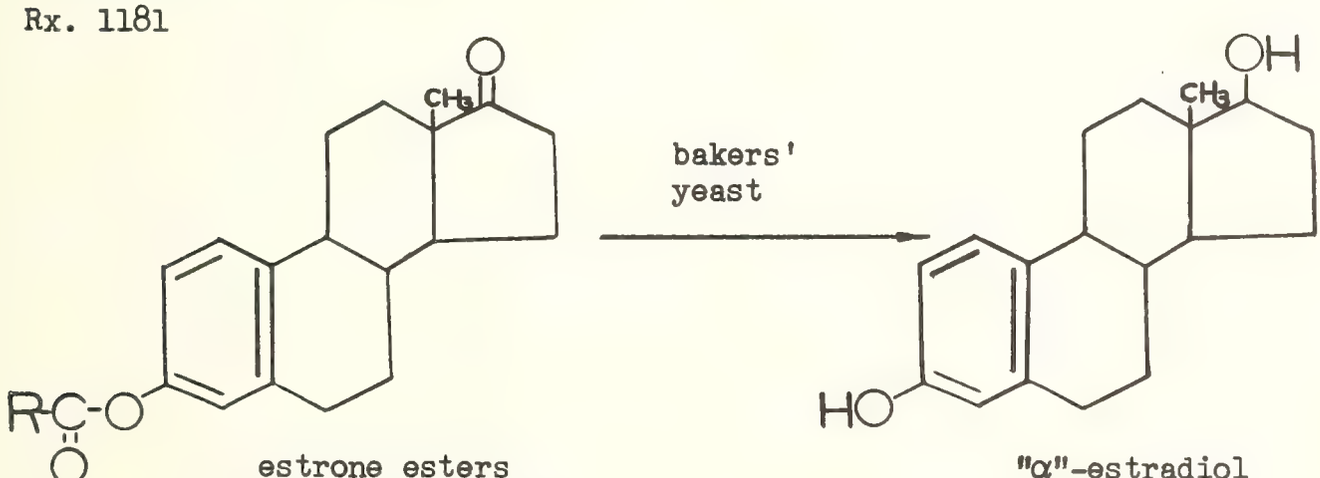
triolein

fatty acid (oleic acid)

Mamoli, Ber. 71B, 2696-8 (1938).

C.A. 33, 2156[8] (1939).

Rx. 1181



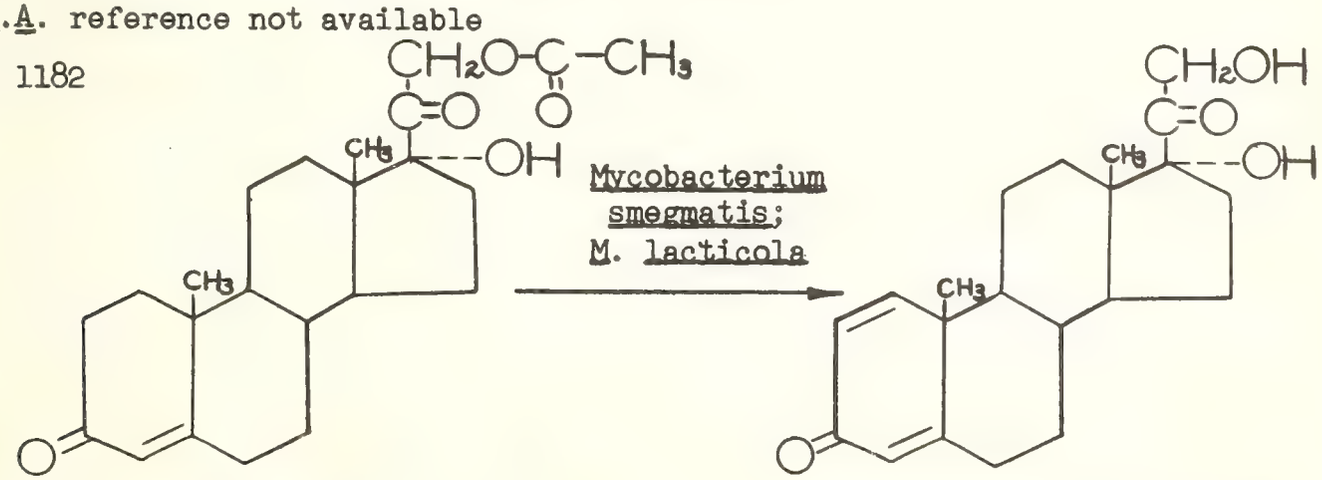
estrone esters (3-acyloxy estrone)

"α"-estradiol

Shull and Kita, Belg. 538,327 (May 21, 1955).

C.A. reference not available

Rx. 1182



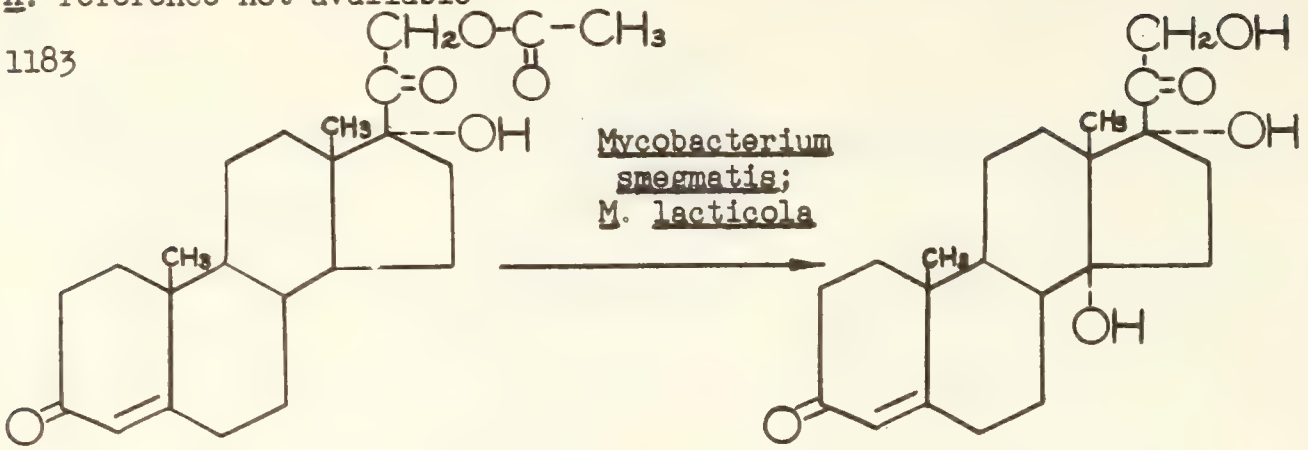
21-O-acetyl-Δ^4-pregnene-17α, 21-diol-3,20-dione

$\Delta^{1,4}$-pregnadiene-17α,21-diol-3,20-dione

Shull and Kita, Belg. 538,327 (May 21, 1955).

C.A. reference not available

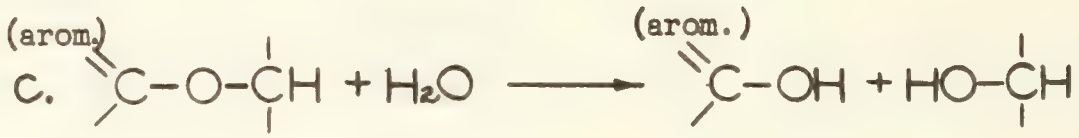
Rx. 1183



21-O-acetyl-Δ^4-pregnene-17α,21-diol-3,20-dione

Δ^4-pregnene-14α,17α,21-triol-3,20-dione

VI. Hydrolysis

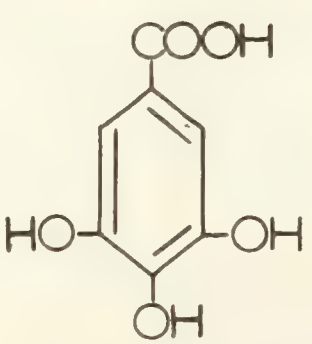


Van Tieghem, Compt. rend. 65, 1091-4 (1867).

Rx. 1184

TANNINS
(a glycoside)

Aspergillus niger; Penicillium glaucum

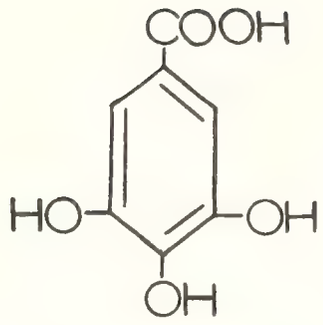


gallic acid

Calmette, Ger. 129,164 (March 1, 1902).

Rx. 1185

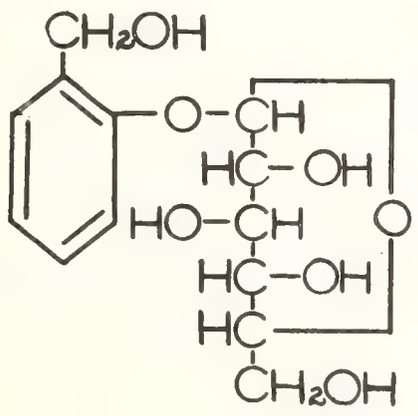
TANNIN —(Aspergillus gallomyces Apparently a varient of A. niger)→ gallic acid



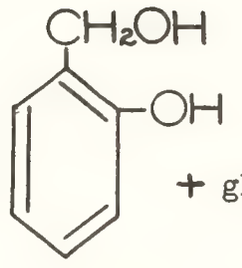
Supniewski, Biochem. Z. 146, 522-35 (1924).

C.A. 19, 311[8] (1925).

Rx. 1186

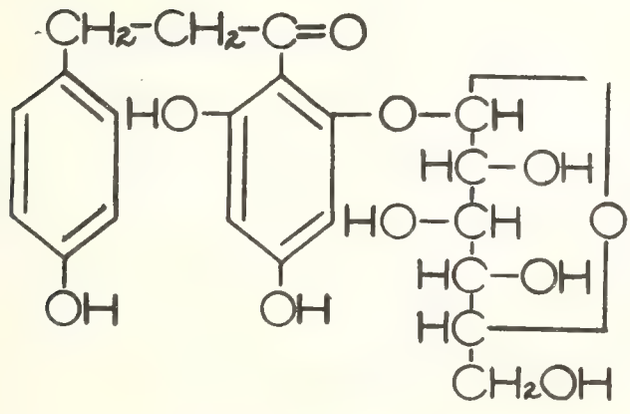


salicin —(Pseudomonas aeruginosa (Bacillus pyocyaneus))→ saligenin + glucose

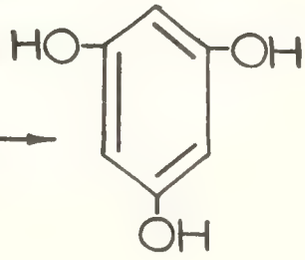


Boas, Zentr. Bakt. Parasitenk. II Abt. 44, 695-701 (1916).

Rx. 1187



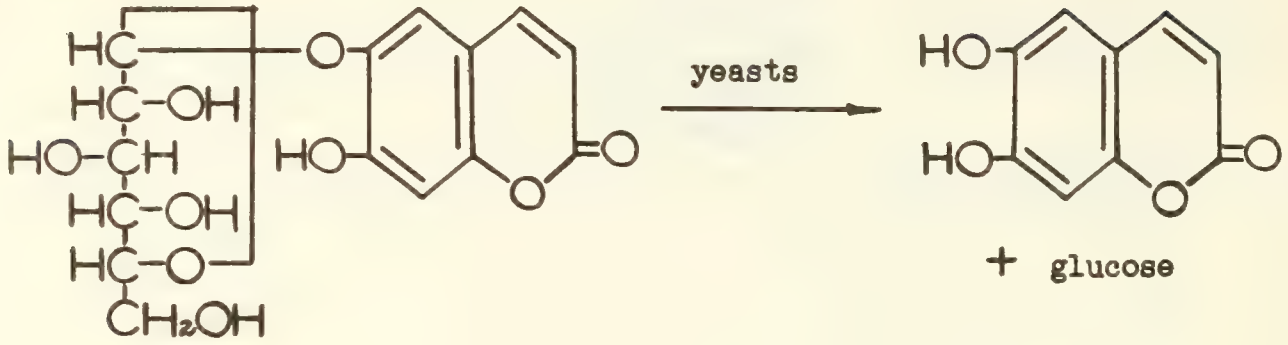
phloridzin —(Cladosporium sp.; Aspergillus niger; A. oryzae)→ phloroglucinol



Barnett and Swain, Nature 177, 133-4 (1956).

C.A. 50, 7401f (1956).

Rx. 1188



aesculin — aesculetin

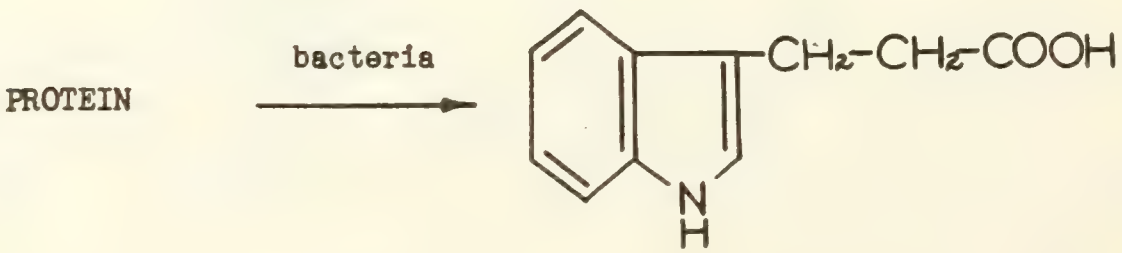
VI. Hydrolysis

d. Proteins and amino acids

Salkowski, Z. physiol. Chem. 27, 297-323 (1899).

Brit. C.A. 76 [ii], 567 (1899).

Rx. 1189

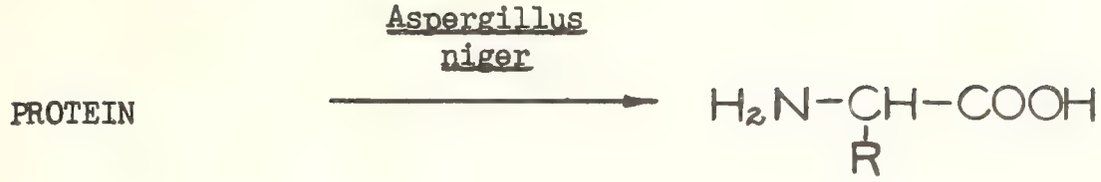


β-(3-indolyl)-propionic acid

Kirch, Food Research 4, 363-70 (1939).

C.A. 33, 8669[7] (1939).

Rx. 1190

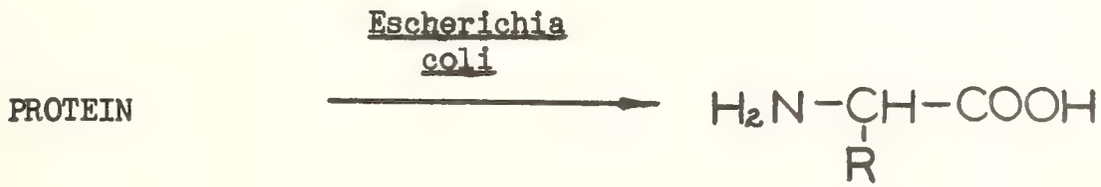


peptones and amino acids

Podolsky, Arch. Biochem. Biophys. 45, 327-40 (1953).

C.A. 47, 11343g (1953).

Rx. 1191



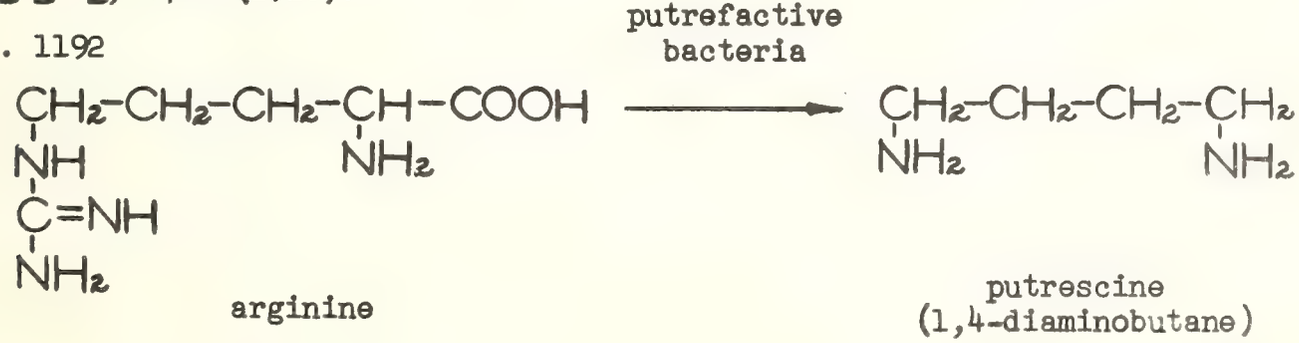
free amino acids

VI. Hydrolysis

Ackermann, Z. physiol. Chem. 60, 482-501 (1909).

C.A. 4, 474[8] (1910).

Rx. 1192



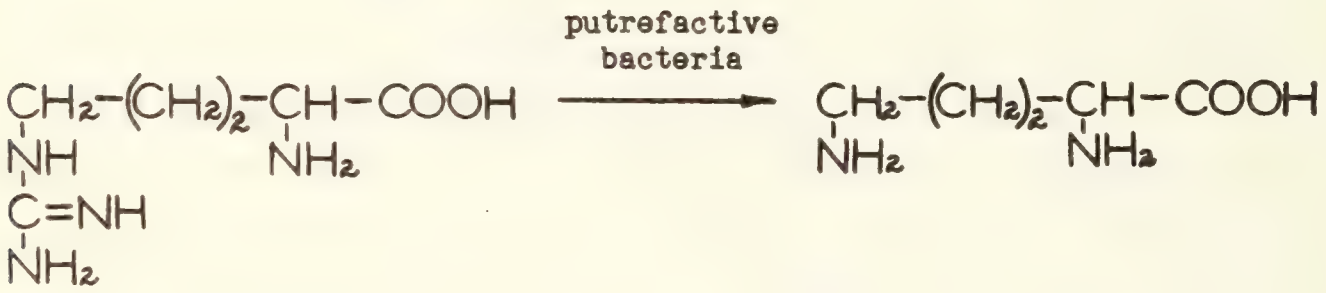
Ackermann, Z. physiol. Chem. 60, 482-501 (1909).
C.A. 4, 474[8] (1910).

Rx. 1193

arginine → δ-aminovaleric acid

Ackermann, Z. physiol. Chem. 56, 305-15 (1908).
C.A. 3, 1414[4] (1909).

Rx. 1194



d-arginine → i-ornithine

Schmidt et al., J. Biol. Chem. 198, 771-83 (1952).
C.A. 47, 655i (1953).

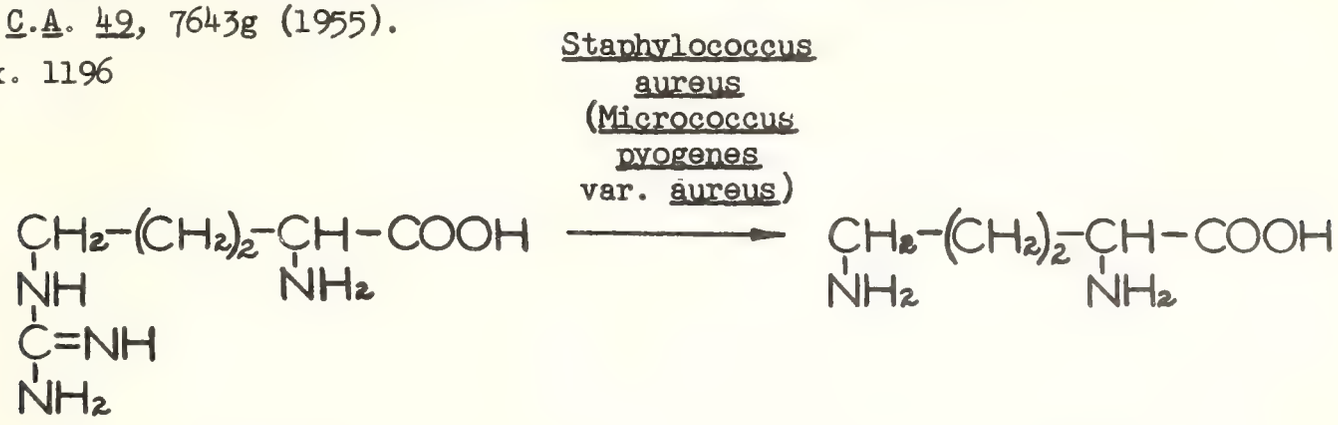
Rx. 1195

arginine → ornithine

Jackson and Pasieka, Can. J. Microbiol. 1, 339-45 (1955).

C.A. 49, 7643g (1955).

Rx. 1196



arginine — ornithine (approx. 80%)

Linneweh, Z. physiol. Chem. 200, 115-8 (1931).

C.A. 25, 5443[6] (1931).

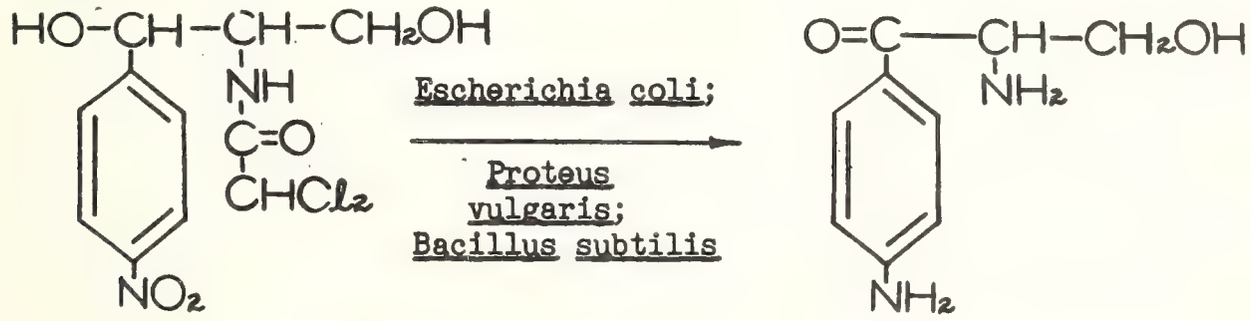
Rx. 1197

arcaine (1,4-diguanidinobutane) — putrescine (41%) (1,4-diaminobutane)

Smith and Worrel, Arch. Biochem. 28, 232-41 (1950).

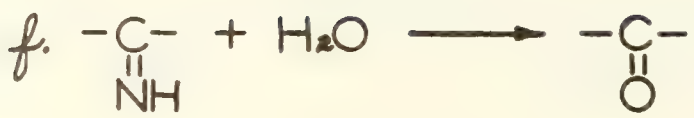
C.A. 45, 3031g (1951).

Rx. 1198



chloramphenicol — α-amino-β-hydroxy-p-aminopropiophenone

VI. Hydrolysis

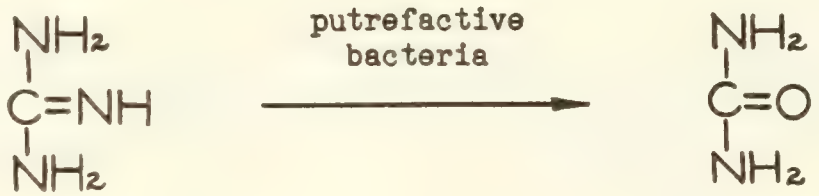


---

ackermann, Z. physiol. Chem. 60, 482-501 (1909).

C.A. 4, 474[8] (1910).

Rx. 1199

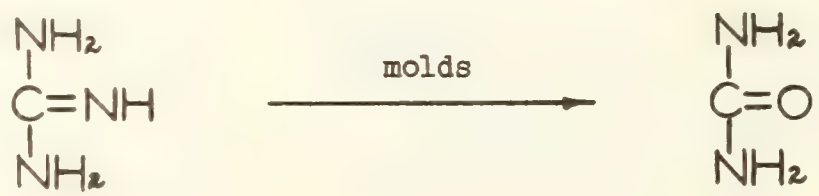


guanidine urea

Chrzaszcz and Zakomorny, Biochem. Z. 275, 97-105 (1935).

C.A. 29, 2575[5] (1935).

Rx. 1200

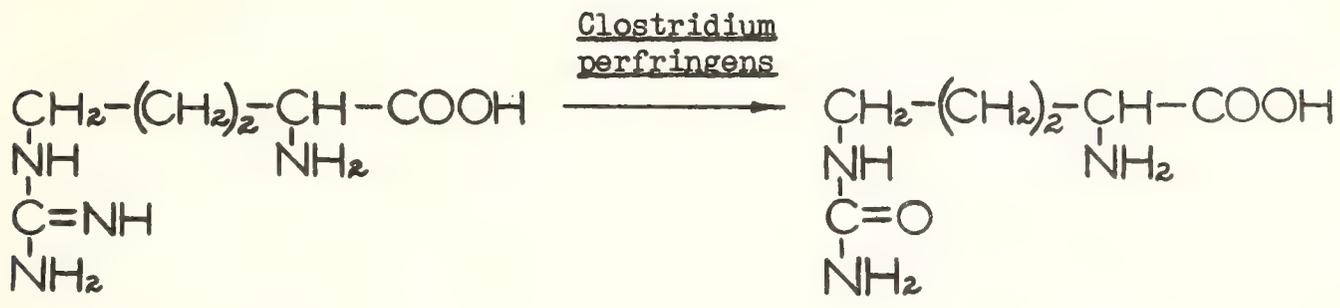


guanidine urea

Schmidt et al., J. Biol. Chem. 198, 771-83 (1952).

C.A. 47, 655i (1953).

Rx. 1201

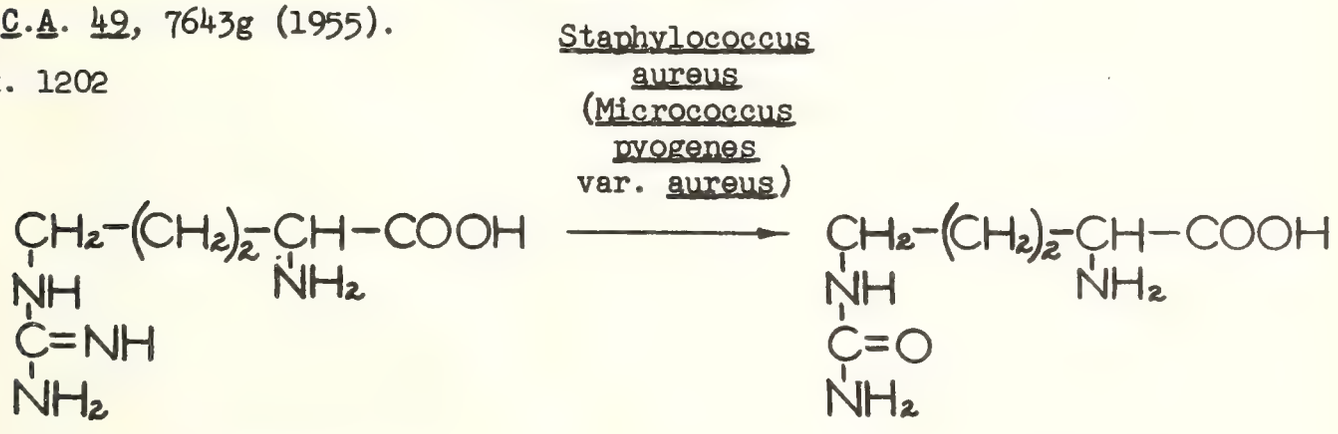


arginine citrulline

Jackson and Pasieka, Can. J. Microbiol. 1, 339-45 (1955).

C.A. 49, 7643g (1955).

Rx. 1202



arginine citrulline

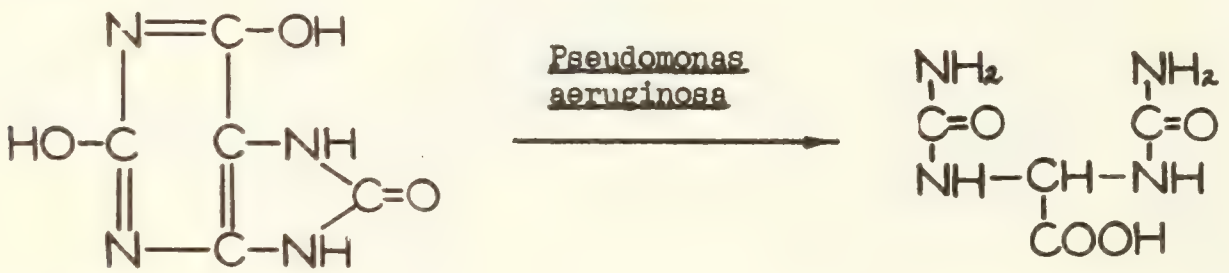
VI. Hydrolysis

g. Miscellaneous types

Franke and Hahn, Z. physiol. Chem. 299, 15-38 (1955).

C.A. 49, 5570h (1955).

Rx. 1203



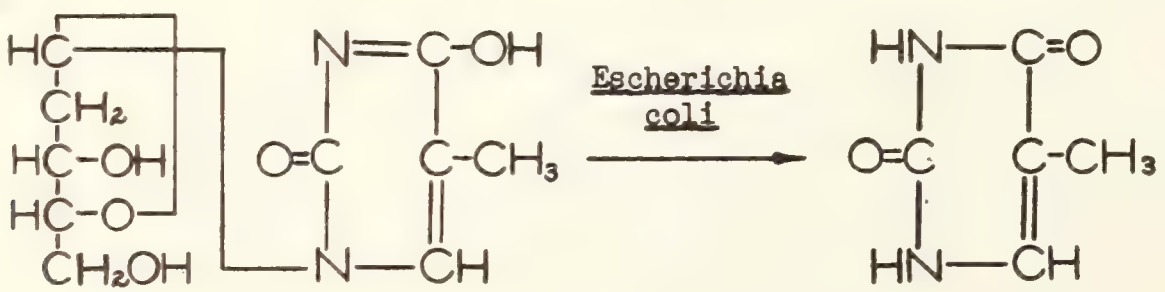
uric acid

allantoic acid

Hoffman and Lampen, J. Biol. Chem. 198, 885-93 (1952).

C.A. 47, 1237f (1953).

Rx. 1204



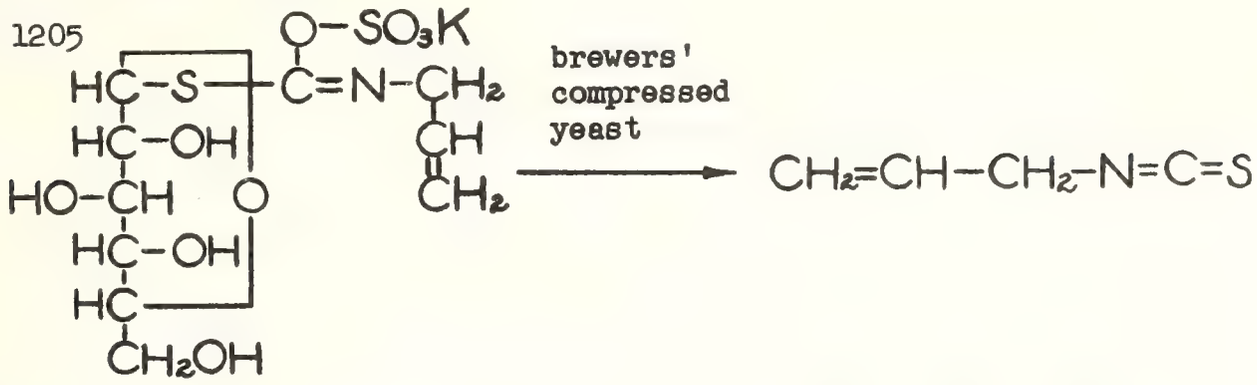
thymidine
(thymine desoxyriboside)

thymine

Bokorny, Biochem. Z. 75, 376-416 (1916).

C.A. 11, 260[9] (1917).

Rx. 1205



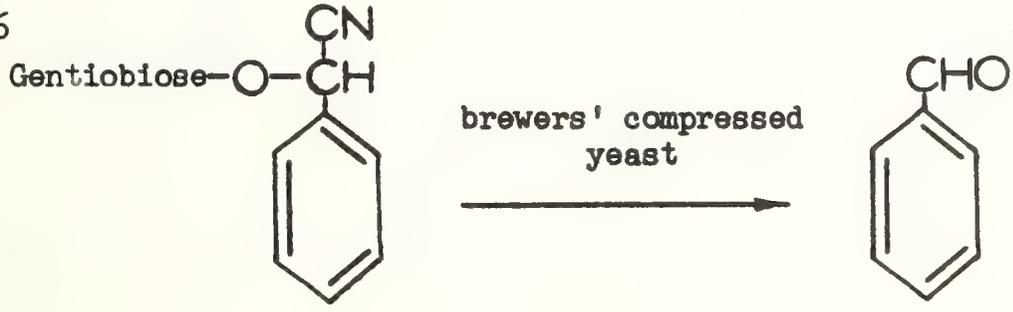
potassium myronate (sinigrin)

allyl isothiocyanate (oil of mustard)

Bokorny, Biochem. Z. 75, 376-416 (1916).

C.A. 11, 260[9] (1917).

Rx. 1206



amygdalin (D-(-)-mandelonitrile-β-gentiobioside)

benzaldehyde

VII. Methylation

a. $SeO_{3(4)}^{=} \longrightarrow CH_3-Se-CH_3$

Challenger and North, J. Chem. Soc., 68-71 (1934).

C.A. 28, 1983[9] (1934).

Rx. 1207

$$Na_2SeO_3 \xrightarrow{\text{Scopulariopsis brevicaulis (Penicillium brevicaule)}} CH_3-Se-CH_3$$

sodium selenite — dimethylselenium

Bird and Challenger, J. Chem. Soc., 163-8 (1939).

C.A. 33, 2483[3] (1939).

Rx. 1208

$$Na_2SeO_3 \xrightarrow{\text{Penicillium chrysogenum; Pen. notatum}} CH_3-Se-CH_3$$

sodium selenite — dimethylselenium

Challenger et al., Chemistry & Industry 128-9 (1953).

C.A. 47, 7596b (1953).

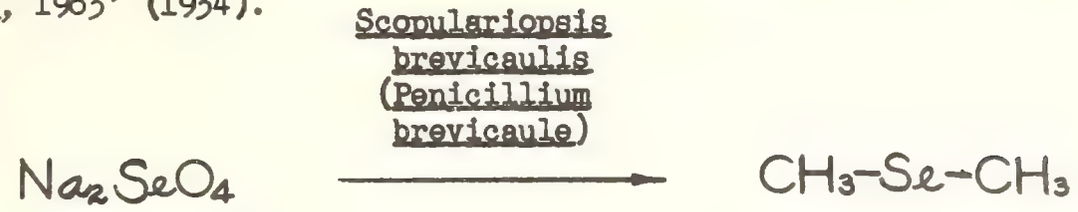
Rx. 1209

$$H_2SeO_3 \xrightarrow{\text{Scopulariopsis brevicaulis; Aspergillus niger plus } C^{14}\text{-labeled donors}} CH_3-Se-CH_3$$

selenous acid (probably a Na or K salt of) — dimethylselenium (labeled)

Challenger and North, J. Chem. Soc., 68-71 (1934).
C.A. 28, 1983[9] (1934).

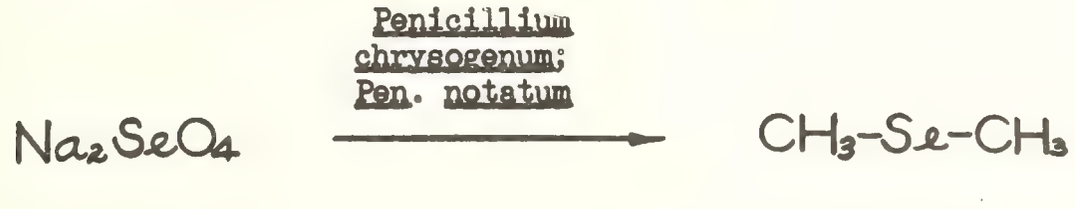
Rx. 1210



sodium selenate — dimethylselenium

Bird and Challenger, J. Chem. Soc., 163-8 (1939).
C.A. 33, 2483[3] (1939).

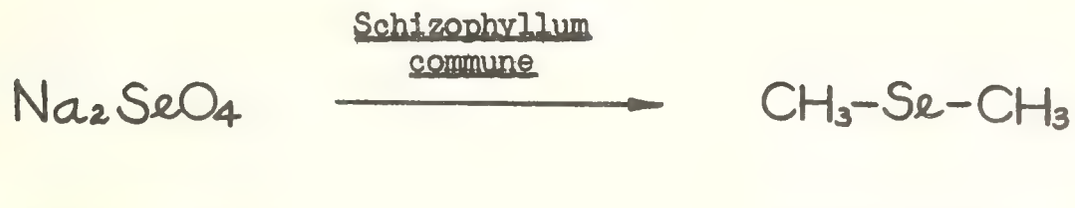
Rx. 1211



sodium selenate — dimethylselenium

Challenger and Charlton, J. Chem. Soc., 424-9 (1947).
C.A. 41, 5578d (1947).

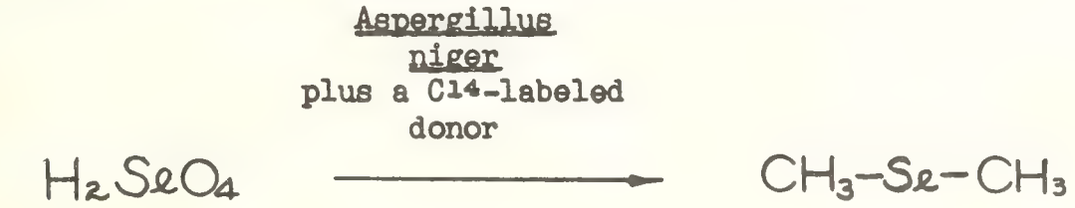
Rx. 1212



sodium selenate — dimethylselenium

Dransfield and Challenger, Biochem. J. 58, xxviii (1954).

Rx. 1213



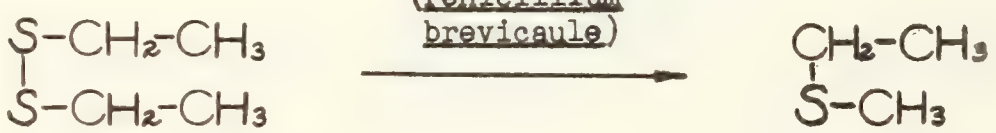
selenates (soluble salts) — dimethylselenium (labeled)

VII. Methylation

b. RS-SR ⟶ RS-CH_3

Challenger and Rawlings, J. Chem. Soc., 868-75 (1937).
C.A. 31, 5321[4] (1937).

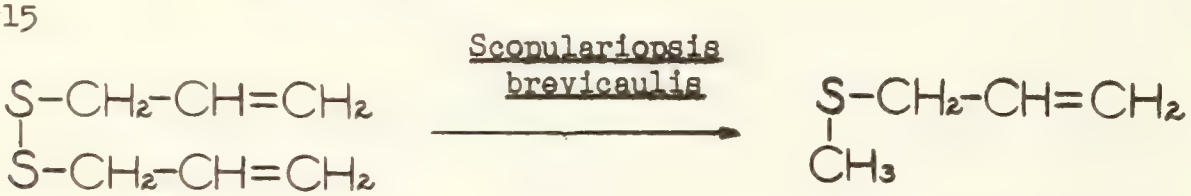
Rx. 1214



diethyldisisulfide — methylethyl sulfide

Challenger and Greenwood, Biochem. J. 44, 87-91 (1949).
C.A. 43, 6286f (1949).

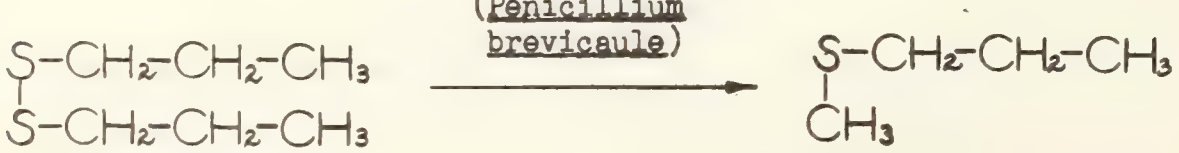
Rx. 1215



diallyl disulfide — methylallyl sulfide

Challenger and Rawlings, J. Chem. Soc., 868-75 (1957). See Chemistry & Industry 55, 155 (1936).
C.A. 31, 5321[4] (1937).

Rx. 1216

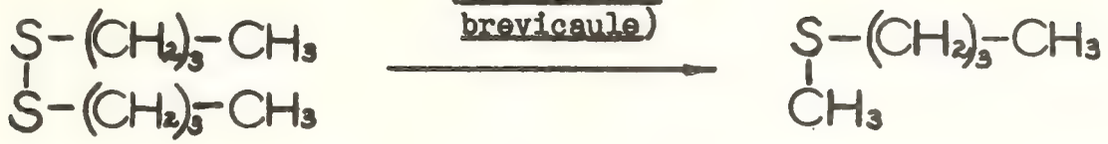


di-n-propyldisulfide — methyl-n-propylsulfide

Blackburn and Challenger, J. Chem. Soc., 1872-8 (1938).

C.A. 33, 1265^3 (1939).

Rx. 1217

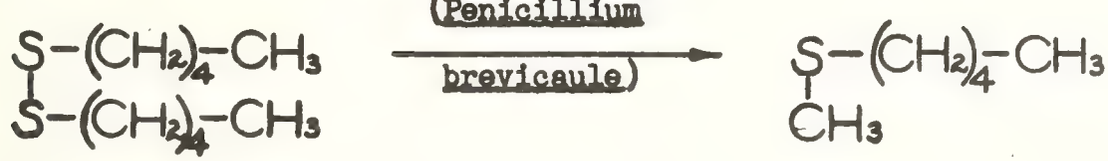


di-n-butyl disulfide → methyl-n-butyl sulfide

Blackburn and Challenger, J. Chem. Soc., 1872-8 (1938).

C.A. 33, 1265^3 (1939).

Rx. 1218



di-n-amyl disulfide → methyl-n-amyl sulfide

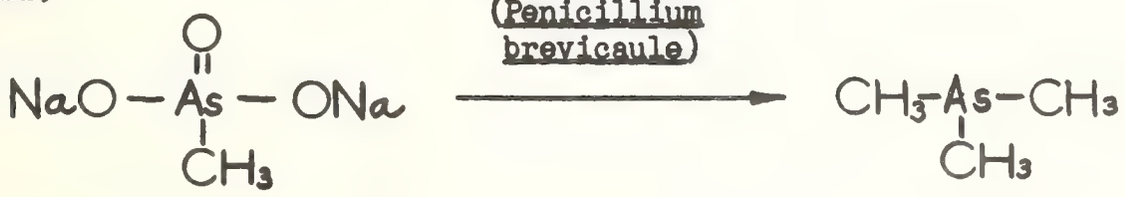
VII. Methylation

c. $RAs(=O)(OH)_2 \longrightarrow RAs(CH_3)_2$

Challenger et al., J. Chem. Soc., 95-101 (1933).

C.A. 27, 1612^3 (1933).

Rx. 1219

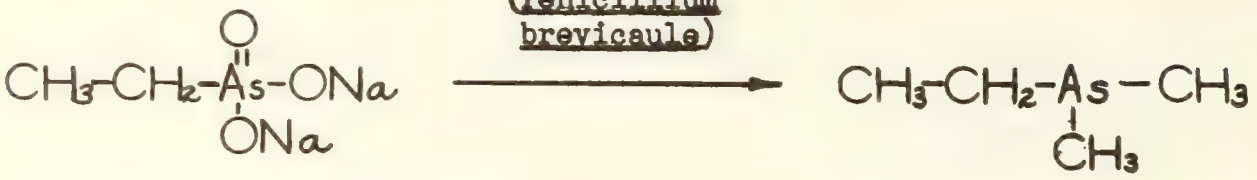


sodium methylarsonate → trimethylarsine

Challenger et al., J. Chem. Soc., 95-101 (1933).

C.A. 27, 1612[3] (1933).

Rx. 1220

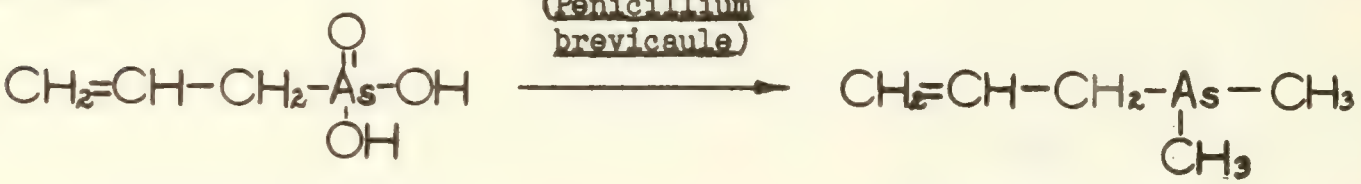


sodium ethylarsonate — dimethylethylarsine

Challenger and Ellis, J. Chem. Soc., 396-400 (1935).

C.A. 29, 3301[8] (1935).

Rx. 1221

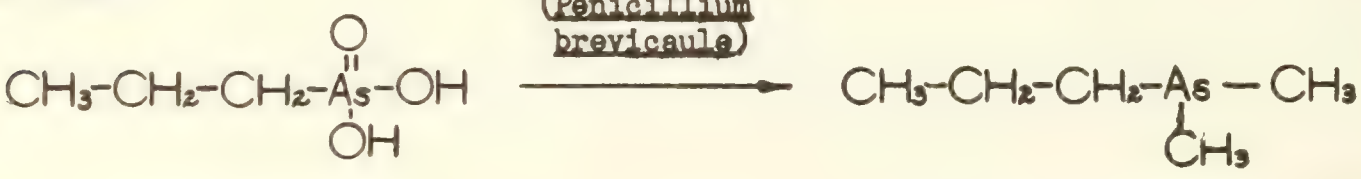


allylarsonic acid — dimethylallylarsine

Challenger and Ellis, J. Chem. Soc., 396-400 (1935).

C.A. 29, 3301[8] (1935).

Rx. 1222

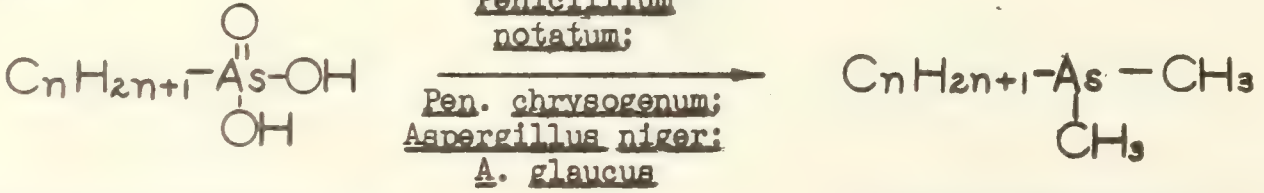


n-propylarsonic acid — dimethyl-n-propylarsine

Bird et al., Biochem. J. 43, 78-83 (1948).

C.A. 43, 2670g (1949).

Rx. 1223



alkanearsonic acid — alkyldimethylarsine

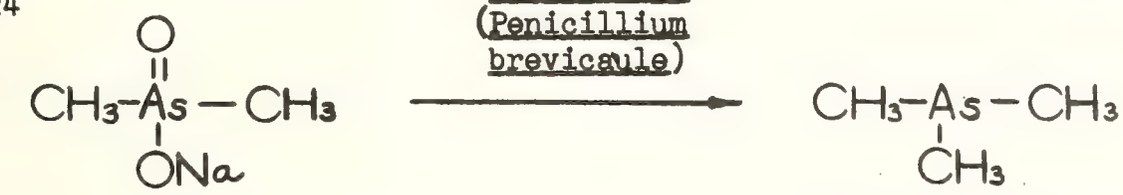
VII. Methylation

d. $R_2As-OH(Na) \longrightarrow R_2As-CH_3$

Challenger et al., J. Chem. Soc., 95-101 (1933).

C.A. 27, 1612[3] (1933).

Rx. 1224

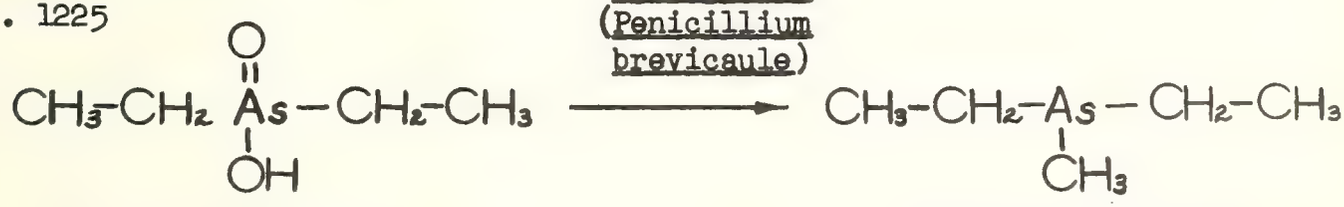


sodium cacodylate — trimethylarsine

Challenger and Ellis, J. Chem. Soc., 396-400 (1935).

C.A. 29, 3301[8] (1935).

Rx. 1225

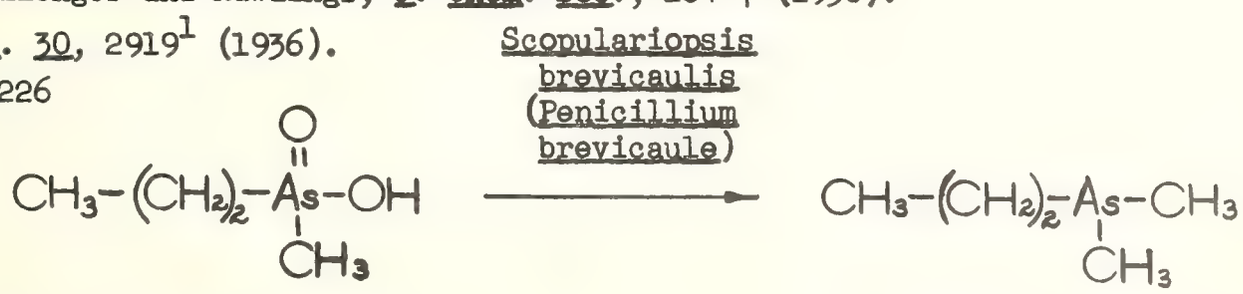


diethylarsinic acid — methyldiethylarsine

Challenger and Rawlings, J. Chem. Soc., 264-7 (1936).

C.A. 30, 2919[1] (1936).

Rx. 1226

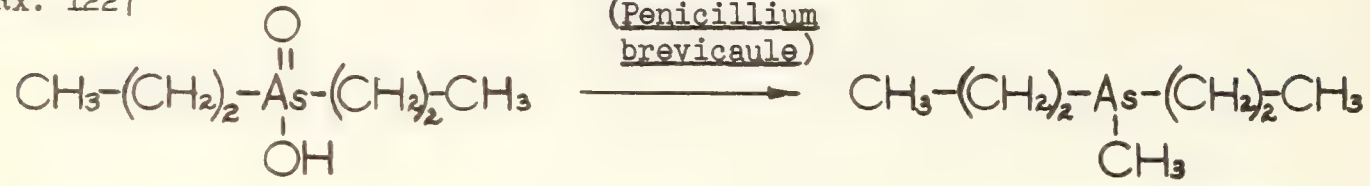


methyl-n-propylarsinic acid — dimethyl-n-propylarsine

Challenger and Rawlings, J. Chem. Soc., 264-7 (1936).

C.A. 30, 2919[1] (1936).

Rx. 1227



ethyl-n-propylarsinic acid — methylethyl-n-propylarsine

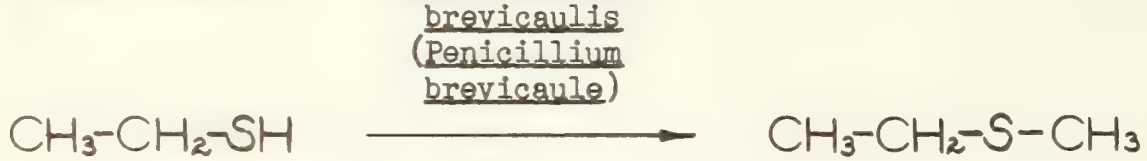
VII. Methylation

ℓ. Miscellaneous types

Challenger and Rawlings, J. Chem. Soc., 868-75 (1937).

C.A. 31, 5321[4] (1937).

Rx. 1228

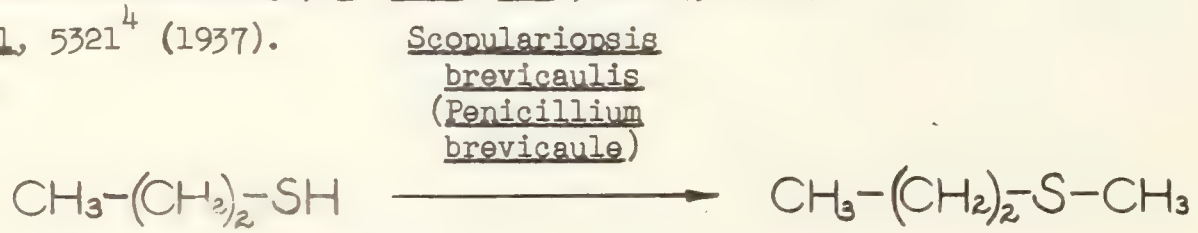


ethyl mercaptan — methylethyl sulfide

Challenger and Rawlings, J. Chem. Soc., 868-75 (1937).

C.A. 31, 5321[4] (1937).

Rx. 1229

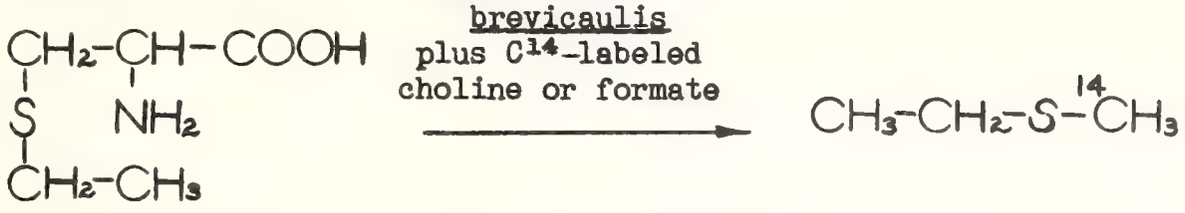


n-propyl mercaptan — methyl-n-propyl sulfide

Challenger et al., Chemistry & Industry, 128-9 (1953).

C.A. 47, 7596b (1953).

Rx. 1230



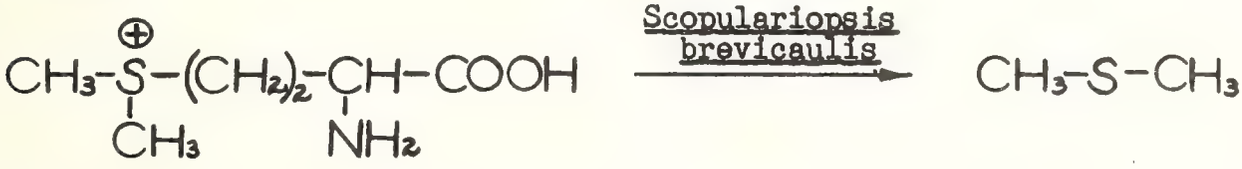
S-ethylcysteine

C^{14}-methylethyl sulfide

Challenger and Charlton, J. Chem. Soc., 424-9 (1947).

C.A. 41, 5578d (1947).

Rx. 1231



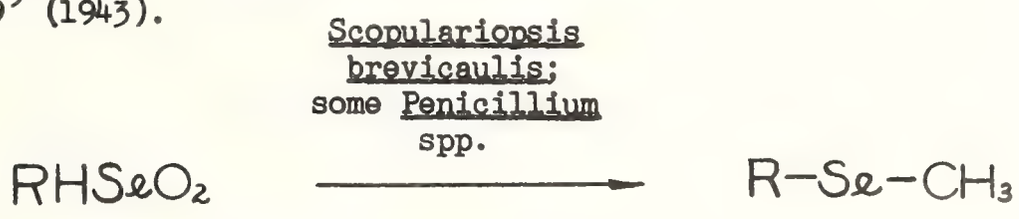
d,l-methionine methiodide

dimethylsulfide

Bird and Challenger, J. Chem. Soc., 574-7 (1942).

C.A. 37, 4099 (1943).

Rx. 1232



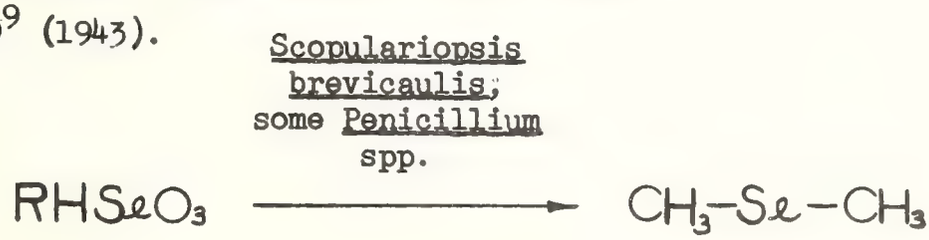
alkyl seleninic acid (Na salt)

methylalkylselenide

Bird and Challenger, J. Chem. Soc., 574-7 (1942).

C.A. 37, 4099 (1943).

Rx. 1233

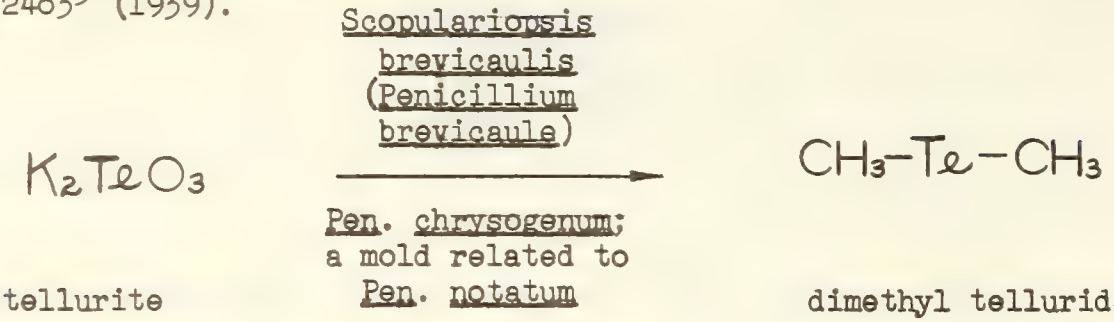


alkyl selenonic acid (K salt)

dimethylselenium

Bird and Challenger, J. Chem. Soc., 163-8 (1939).
C.A. 33, 2483[3] (1939).

Rx. 1234

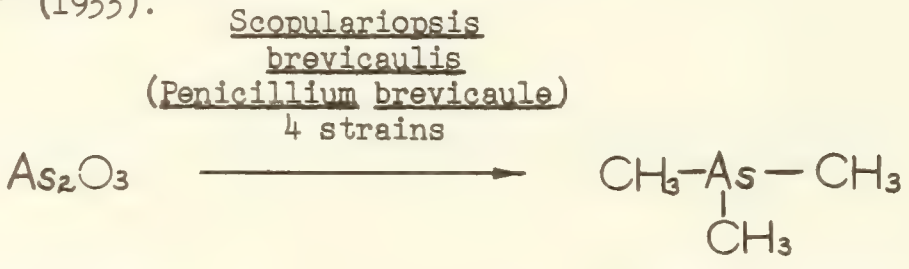


K_2TeO_3 → $CH_3-Te-CH_3$

potassium tellurite — dimethyl telluride

Challenger et al., J. Chem. Soc., 95-101 (1933).
C.A. 27, 1612[3] (1933).

Rx. 1235

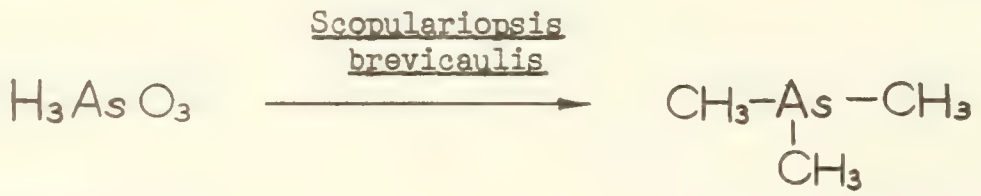


As_2O_3 → $CH_3-As(CH_3)-CH_3$

arsenic trioxide — trimethylarsine

Challenger, Chemistry & Industry, 61, 397-99 (1942).
C.A. 37, 1465 (1943).

Rx. 1236

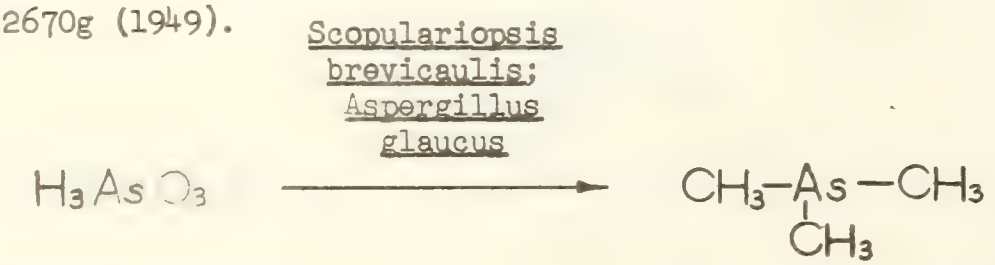


H_3AsO_3 → $CH_3-As(CH_3)-CH_3$

arsenious acid — trimethylarsine

Bird et al., Biochem. J. 43, 78-83 (1948).
C.A. 43, 2670g (1949).

Rx. 1237



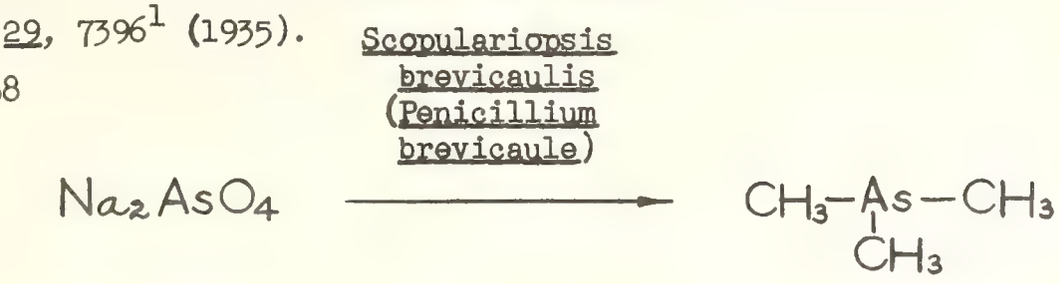
H_3AsO_3 → $CH_3-As(CH_3)-CH_3$

arsenious acid — trimethylarsine

Challenger and Higginbottom, J. Chem. Soc., 1757-78 (1935).

C.A. 29, 7396[1] (1935).

Rx. 1238



sodium arsenate — trimethylarsine

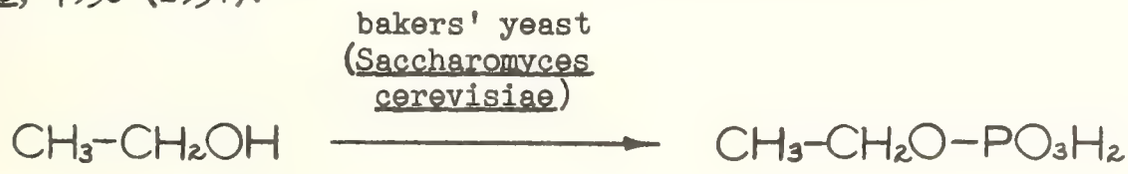
VIII. Esterification

a. $ROH + H_3PO_4 \longrightarrow RO-PO_3H_2$

Szulmajster et al., Bull. soc. chim. biol. 35, 455-65 (1953).

C.A. 48, 795c (1954).

Rx. 1239

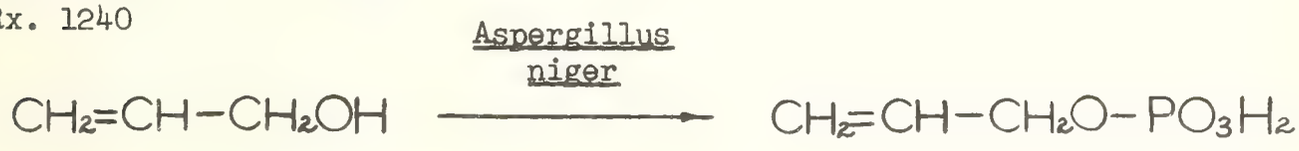


ethanol — ethyl phosphate

Baba, J. Agr. Chem. Soc. Japan 19, 183-6 (1943).

C.A. 45, 3025i (1951).

Rx. 1240

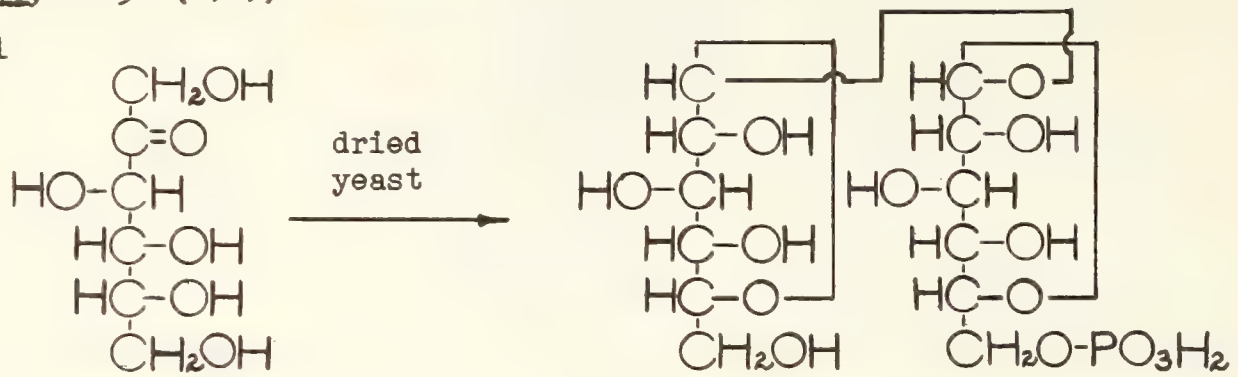


2-propenol-1 (allyl alcohol) — monoallylphosphoric acid

Robison and Morgan, Biochem. J. 22, 1277-88 (1928).

C.A. 23, 1115[9] (1929).

Rx. 1241

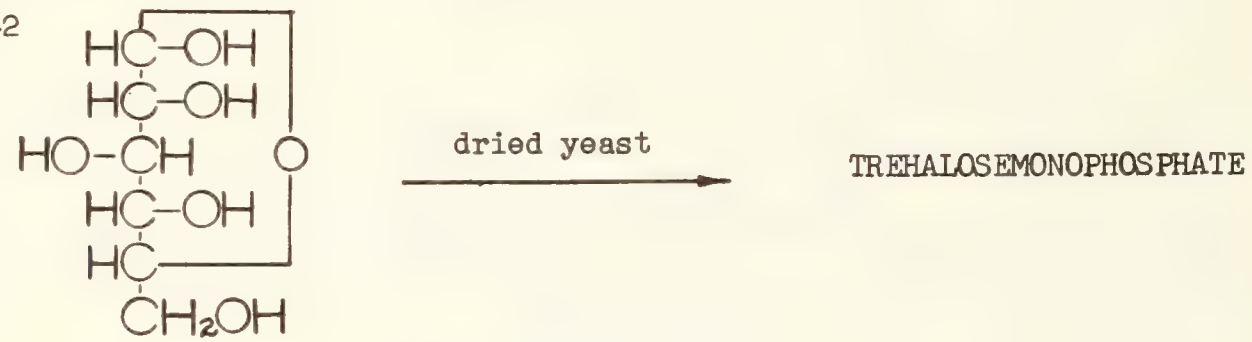


fructose — trehalosemonophosphate

Robison and Morgan, Biochem. J. 24, 119-32 (1930).

C.A. 24, 5420[4] (1930).

Rx. 1242

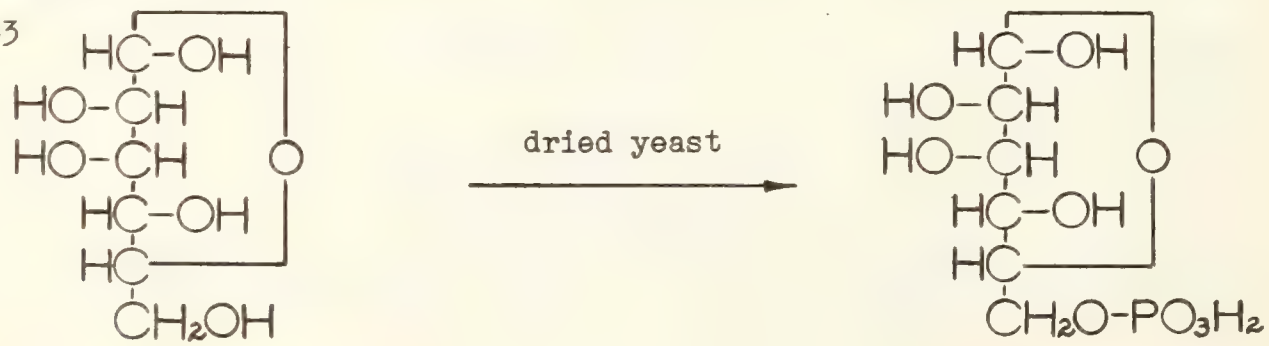


glucose

Jephcott and Robison, Biochem. J. 28, 1844-53 (1934). See Robison, ibid. 26, 2191 (1932).

C.A. 29, 1931[4] (1935).

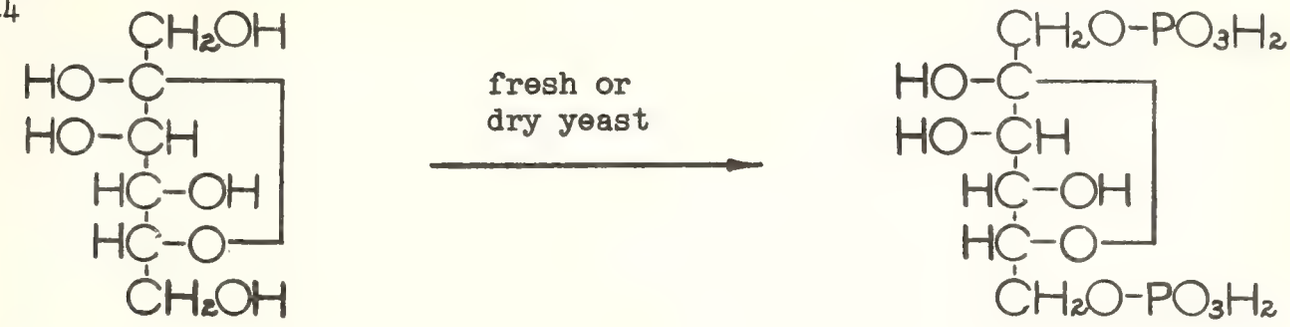
Rx. 1243



mannose — mannose monophosphate

Baba, Bull. Fac. Eng., Hiroshima Univ. 4, 295-302 (1955). See Young, Proc. Chem. Soc. 23, 65 (1907).
C.A. 50, 3704f (1956).

Rx. 1244

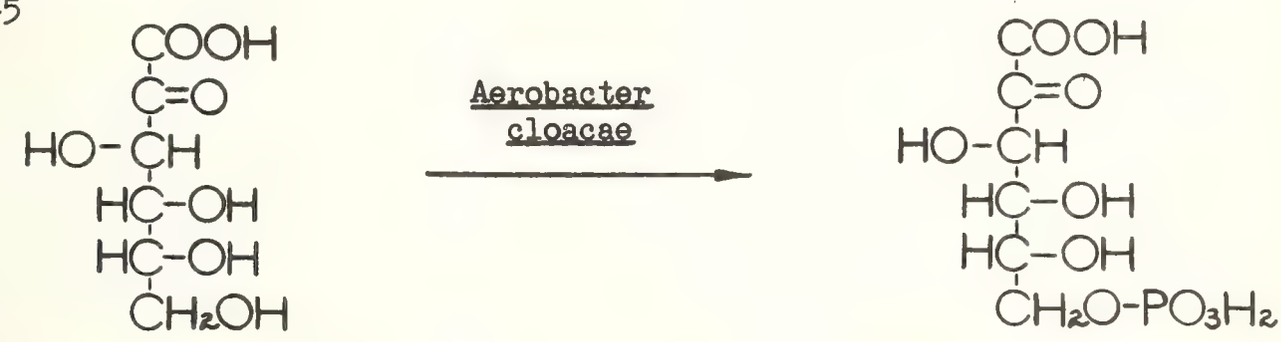


fructose (from molasses)

fructose-1,6-diphosphate (67-69%)

DeLey, Enzymologia 16, 99-104 (1953).
C.A. 48, 7687h (1954).

Rx. 1245

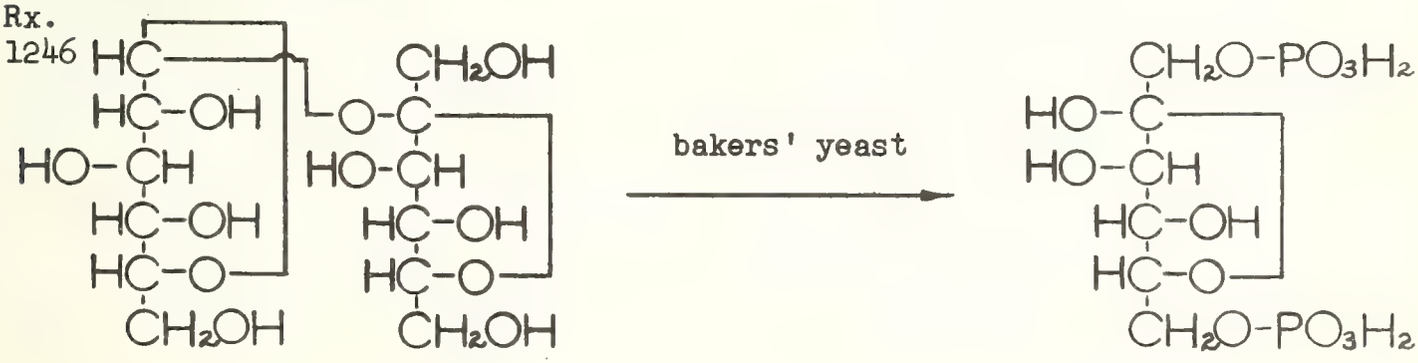


2-keto-D-gluconic acid

2-keto-D-gluconic acid-6-phosphate

Neuberg and Lustig, J. Am. Chem. Soc. 64, 2722-3 (1942).
C.A. 37, 4097 (1943).

Rx. 1246



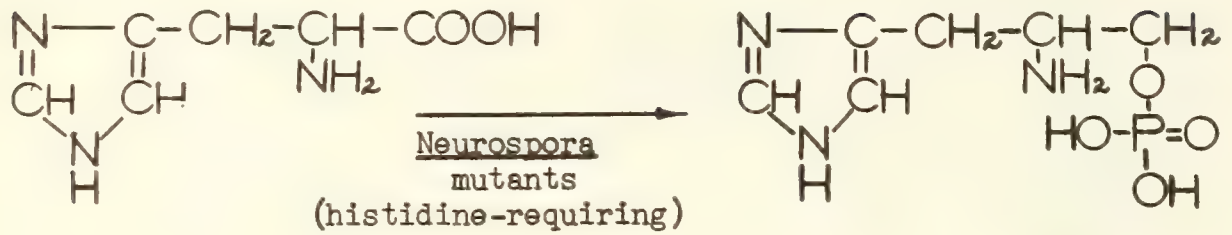
sucrose

D-fructose-1,6-diphosphate

Ames and Mitchell, J. Biol. Chem. 212, 687-96 (1955).

C.A. 49, 7057h (1955).

Rx. 1247



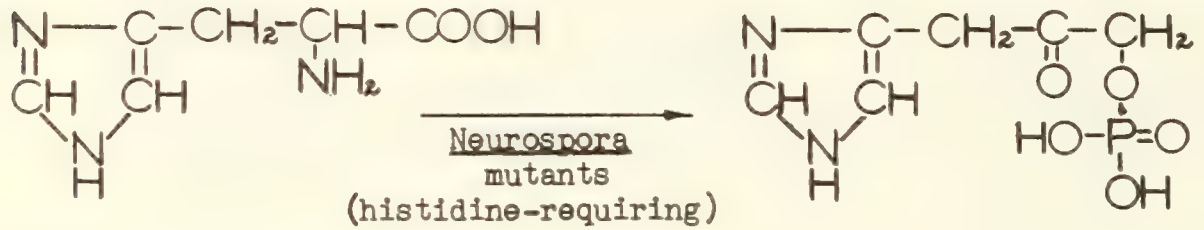
histidine

L-histidinol phosphate

Ames and Mitchell, J. Biol. Chem. 212, 687-96 (1955).

C.A. 49, 7057h (1955).

Rx. 1248



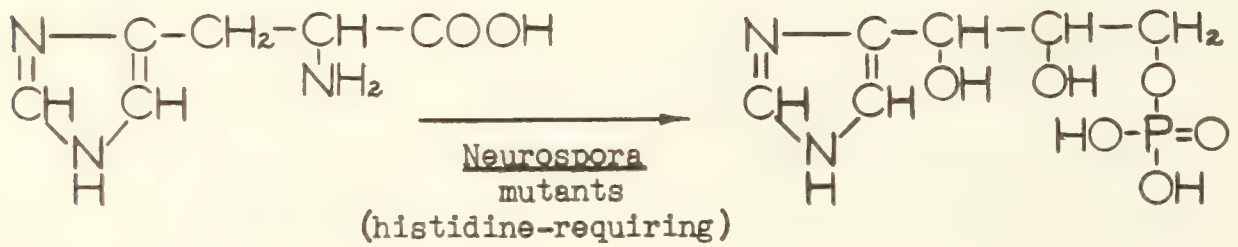
histidine

imidazole-acetol phosphate

Ames and Mitchell, J. Biol. Chem. 212, 687-96 (1955).

C.A. 49, 7057h (1955).

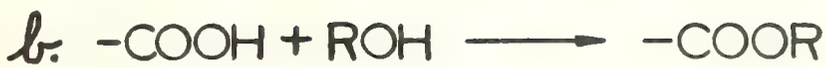
Rx. 1249



histidine

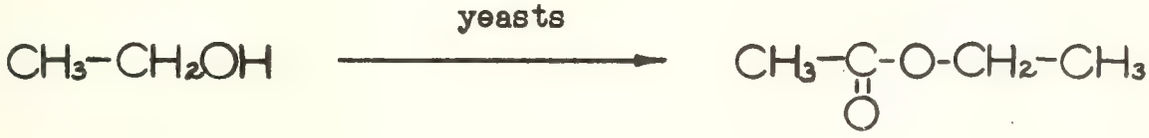
D-erythro-imidazole-glycerol phosphate

VIII. Esterification



Kayser, Compt. rend. 155, 185-7 (1912).
C.A. 6, 3444[1] (1912).

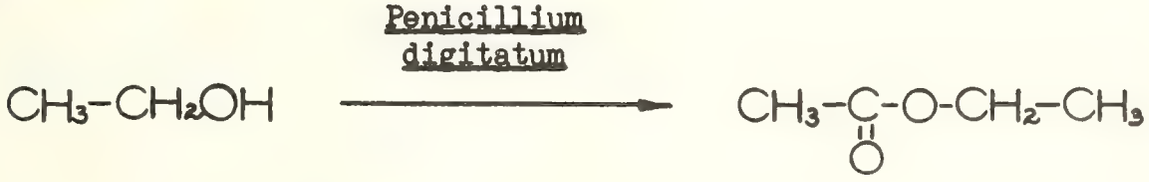
Rx. 1250



ethanol (from sucrose fermentation) — ethyl acetate

Birkinshaw et al., Trans. Roy. Soc. (London) B220, 355-67 (1931).
C.A. 26, 2487[3] (1932).

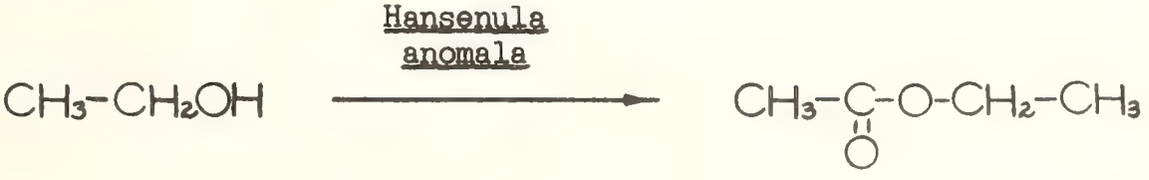
Rx. 1251



ethanol (from glucose fermentation) — ethyl acetate

Gray, Am. J. Botany 36, 475-80 (1949). See Peel, Biochem. J. 49, 62-7 (1951).
C.A. 43, 7550a (1949).

Rx. 1252

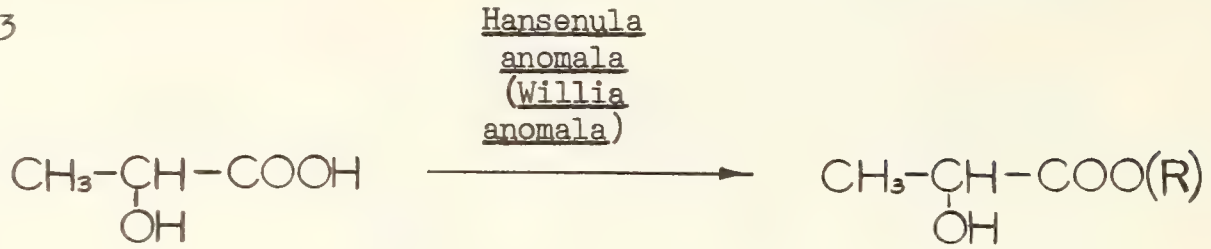


ethanol (from carbohydrate fermentation) — ethyl acetate

Ishikawa, Japan. 1300 (April 18, 1950).

C.A. 46, 7620f (1952).

Rx. 1253

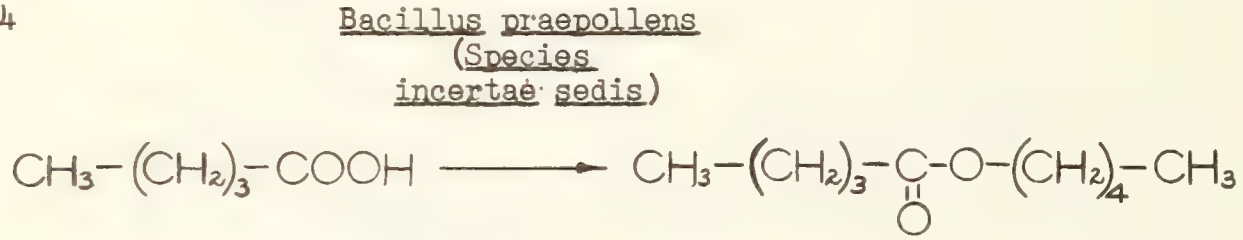


lactic acid — lactate esters

Maassen, Arb. Kais. Ges.-A. 15, 500-13 (1899).

Brit. C.A. 78 [ii], 231-2 (1900).

Rx. 1254

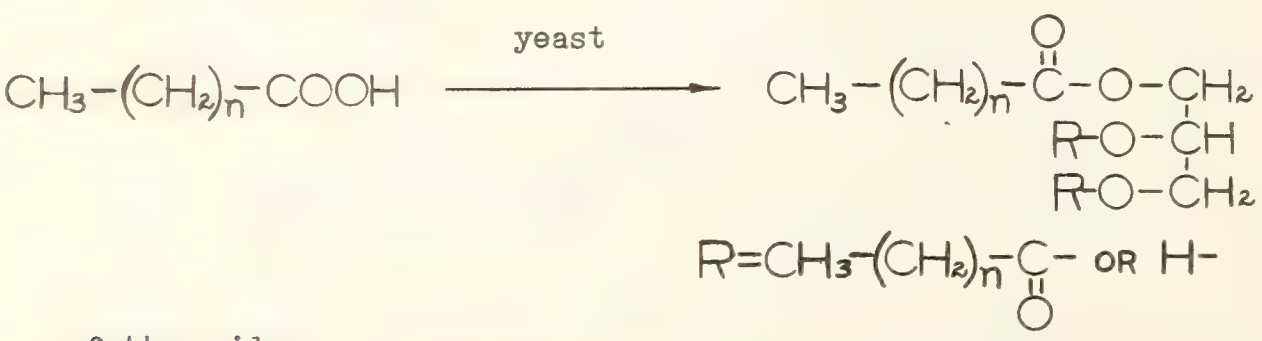


n-valeric acid — probably n-amyl valerate

Kim, Enzymologia 6, 183-5 (1939).

C.A. 33, 8642[7] (1939).

Rx. 1255

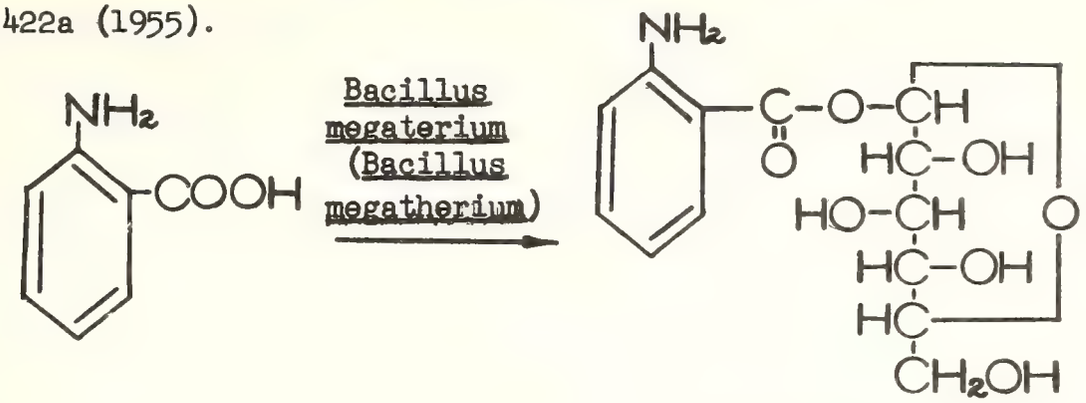


fatty acids — glyceride esters

Tabone and Tabone, Bull. soc. chim. biol. 36, 561-3 (1954).

C.A. 49, 422a (1955).

Rx. 1256



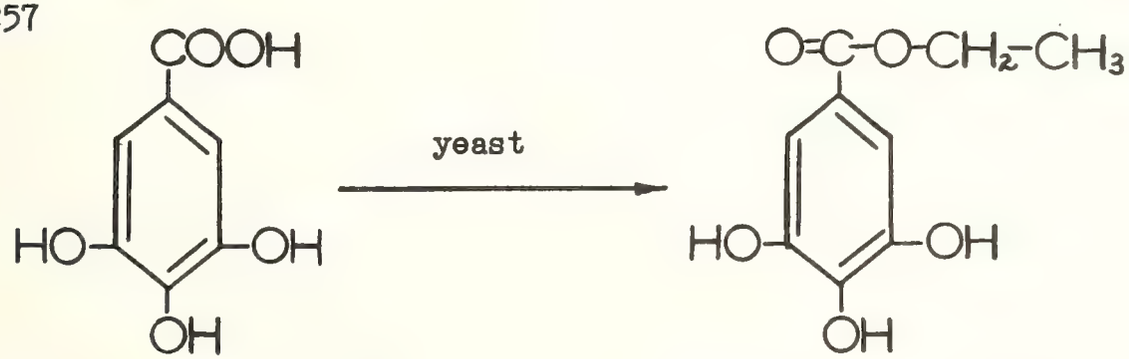
anthranilic acid

1-(anthranilyl)-β-D-glucose

Kim, Enzymologia 6, 183-5 (1939).

C.A. 33, 8642[7] (1939).

Rx. 1257



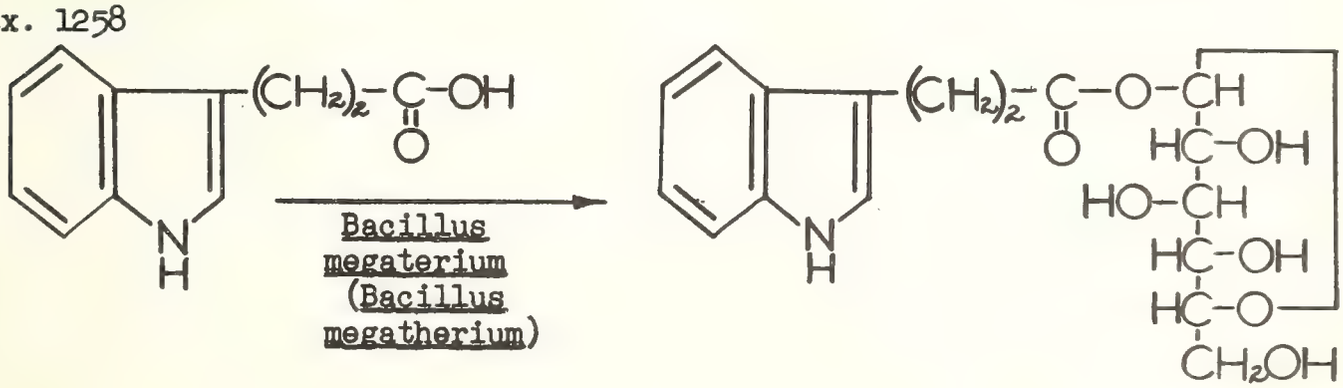
gallic acid

ethyl gallate

Tabone and Robert, Bull. soc. chim. biol. 35, 815-8 (1953).

C.A. 48, 3442f (1954).

Rx. 1258

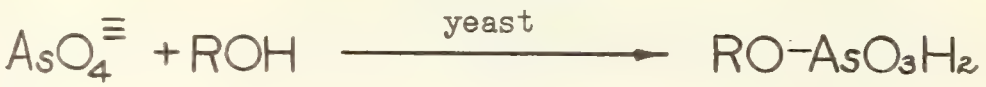


β-(3-indolyl)-propionic acid

1-(indolepropionyl)-β-D-glucose

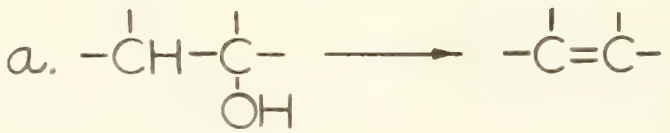
Braunstein and Lewitow, Naturwissenschaften 20, 471 (1932).
C.A. 26, 4840[6] (1932).

Rx. 1259 - Miscellaneous type (Esterification)



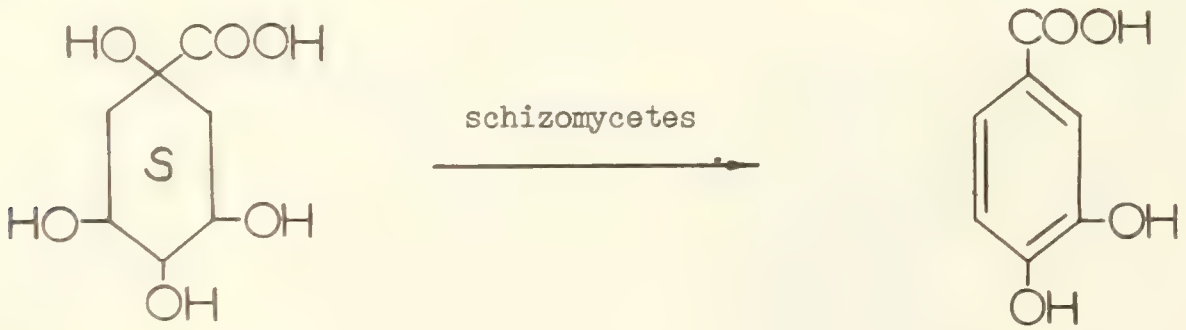
arsenate (plus a hexose, ROH) hexose arsenate ester

IX. Dehydration



Löw, Ber. 14B, 450-2 (1881).
Brit. C.A. 40 [i], 602 (1881).

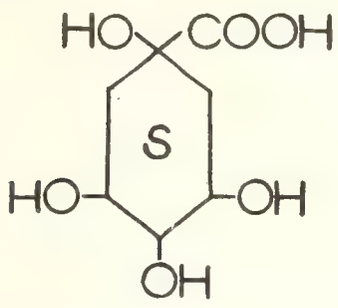
Px. 1260



quinic acid protocatechuic acid

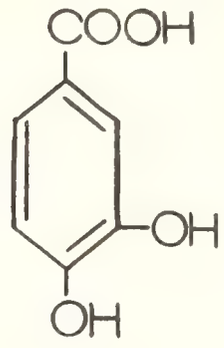
Emmerling and Abderhalden, Zentr. Bakt. Parasitenk. II Abt. 10, 337-9 (1903).
Brit. C.A. 84 [ii], 503 (1903).

Rx. 1261



quinic acid

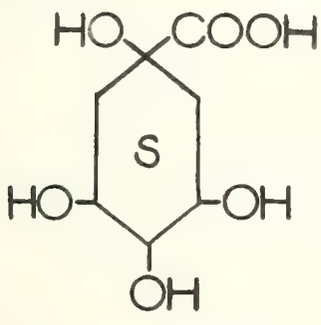
Micrococcus chinicus (Species incertae sedis)



protocatechuic acid

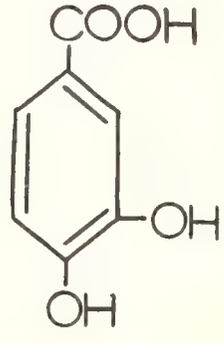
Beijerinck, Proc. Acad. Wetenschappen 13, 1066-77 (1911).
C.A. 6, 1226[2] (1912).

Rx. 1262



quinic acid

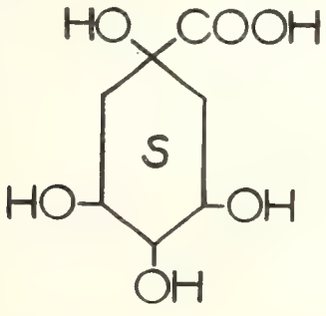
Pseudomonas calco-aceticа (Micrococcus calco-aceticus); Pseudomonas eisenbergii (B. fluorescens non liquefaciens)



protocatechuic acid

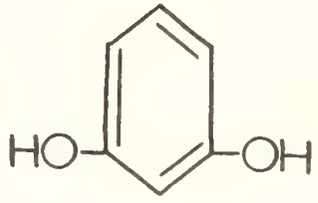
Butkewitsch, Biochem. Z. 145, 442-60 (1924).
C.A. 19, 91[5] (1925).

Rx. 1263



quinic acid

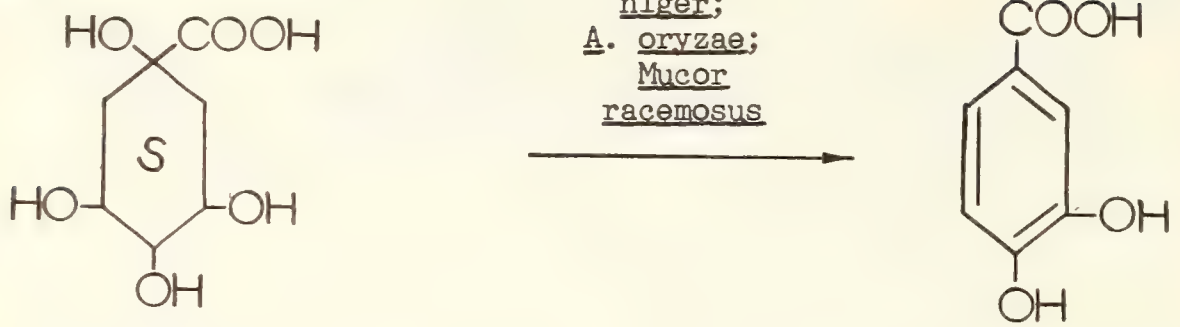
Aspergillus niger; A. oryzae; Mucor racemosus



resorcinol

Butkewitsch, Biochem. Z. 145, 442-60 (1924).
C.A. 19, 91[5] (1925).

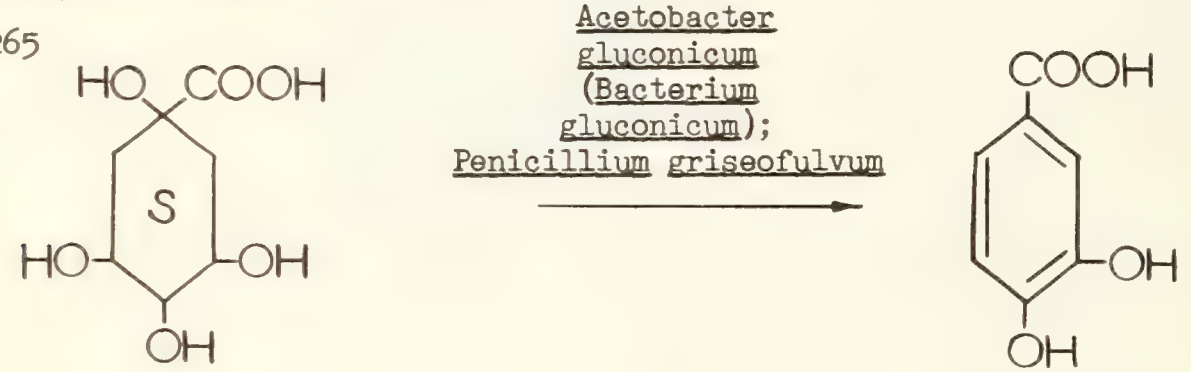
Rx. 1264



quinic acid — protocatechuic acid

Bernhauer and Görlich, Biochem. Z. 280, 394-5 (1935).
C.A. 30, 122[4] (1936).

Rx. 1265



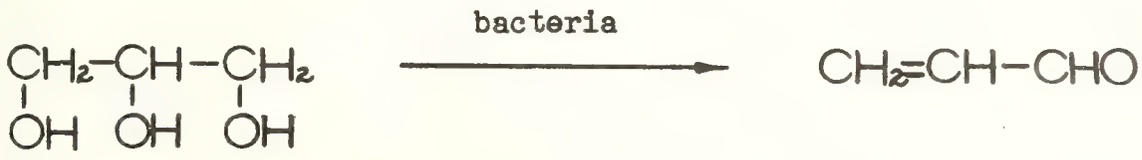
quinic acid — protocatechuic acid

IX. Dehydration

Voisenet, Compt. rend. 150, 1614-16 (1910).

C.A. 4, 2709[1] (1910).

Rx. 1266

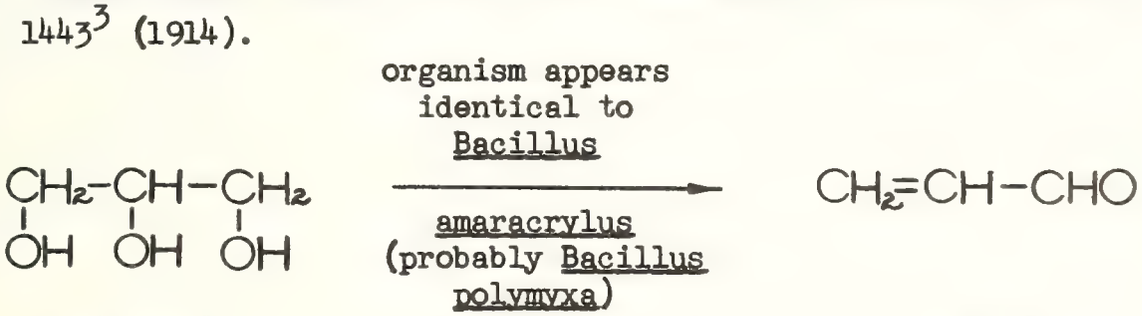


glycerol — acrolein

Voisenet, Compt. rend. 158, 195-7 (1914). See ibid. 153, 363-5 (1911).

C.A. 8, 1443[3] (1914).

Rx. 1267

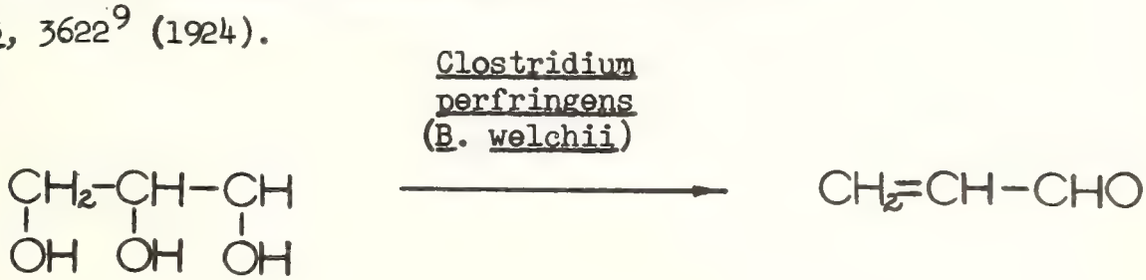


glycerol — acrolein

Humphreys, J. Infectious Diseases 35, 282-90 (1924).

C.A. 18, 3622[9] (1924).

Rx. 1268

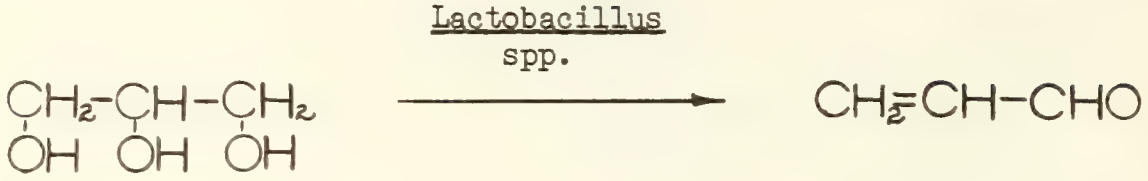


glycerol — acrolein

Serjak et al., Appl. Microbiol. 2, 14-20 (1954).

C.A. 48, 3629e (1954).

Rx. 1269

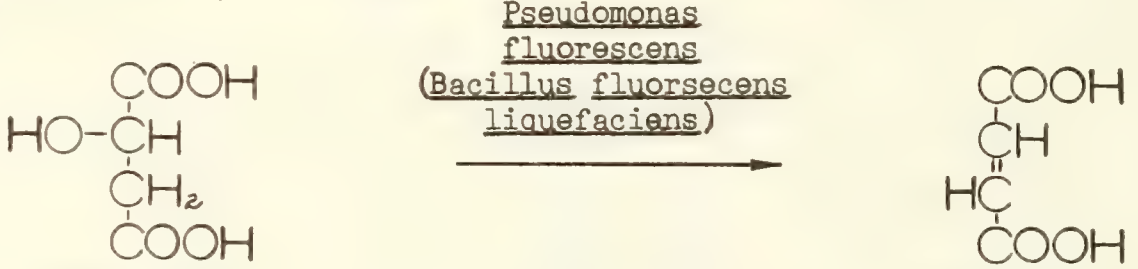


glycerol — acrolein

Emmerling and Reiser, Ber. 35B, 700-2 (1902).

Brit. C.A. 82 [ii], 279 (1902).

Rx. 1270



l-malic acid — fumaric acid

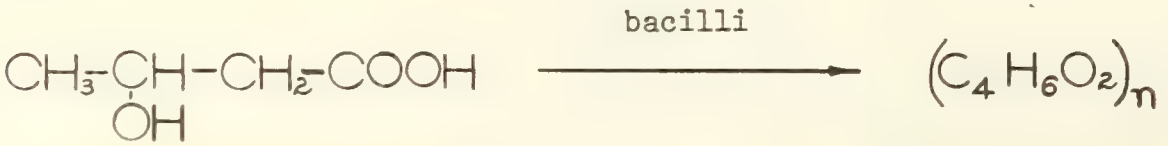
IX. Dehydration

C. Miscellaneous types

Lemoigne, Bull. soc. chim. biol. 8, 770-82 (1926).

C.A. 21, 1133[8] (1927).

Rx. 1271



β-hydroxybutyric acid

dehydration and polymerization products of β-hydroxybutyric acid (n = approx. 6)

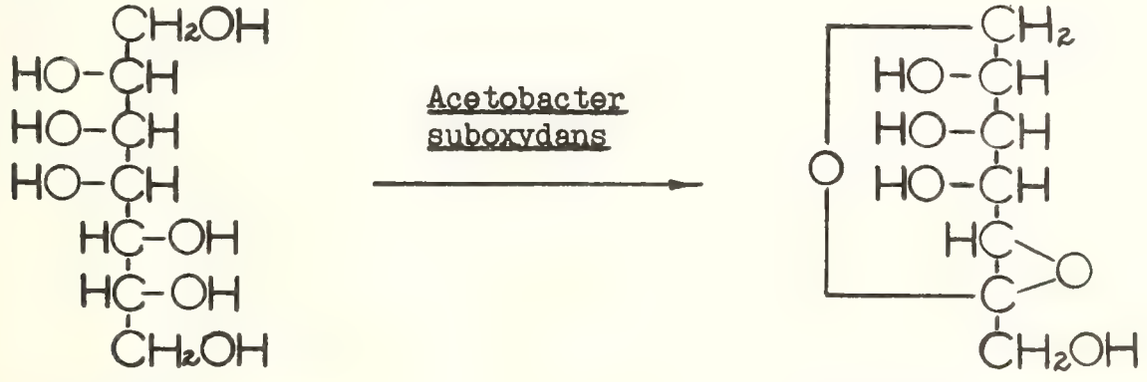
Beijerinck, Proc. Acad. Wetenschappen 13, 1066-77 (1911).
C.A. 6, 1626[2] (1912).

Rx. 1272

d-quercitol — pyrogallol

Stewart et al., J. Am. Chem. Soc. 71, 3532-4 (1949).
C.A. 44, 10799a (1950).

Rx. 1273



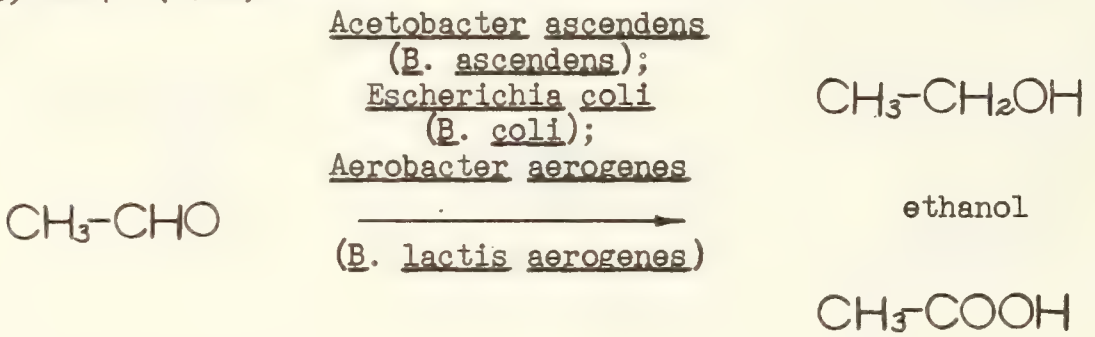
volemitol — sedoheptulosan (27%)

X. Asymmetric Dismutation

$$a.\ -CHO \longrightarrow -CH_2OH + -COOH$$

Neuberg and Windisch, Biochem. Z. 166, 454-81 (1925).
C.A. 20, 2867[6] (1926).

Rx. 1274

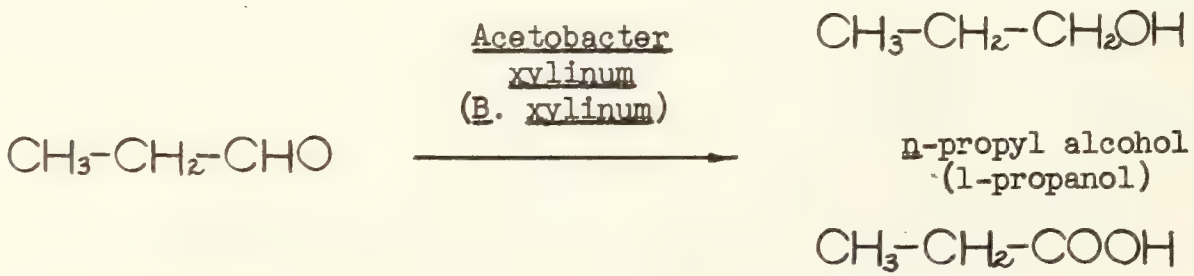


acetaldehyde

acetic acid

Molinari, Biochem. Z. 216, 187-215 (1929).
C.A. 24, 1397[5] (1930).

Rx. 1275

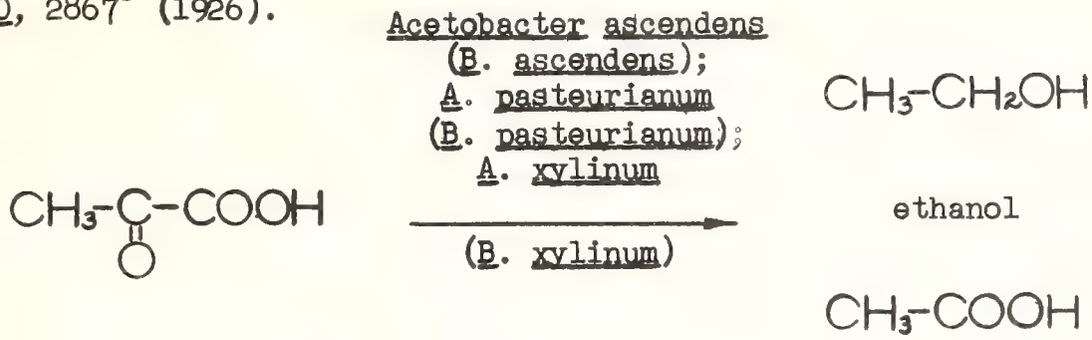


propionaldehyde

propionic acid

Neuberg and Windisch, Biochem. Z. 166, 454-81 (1925).
C.A. 20, 2867[6] (1926).

Rx. 1276

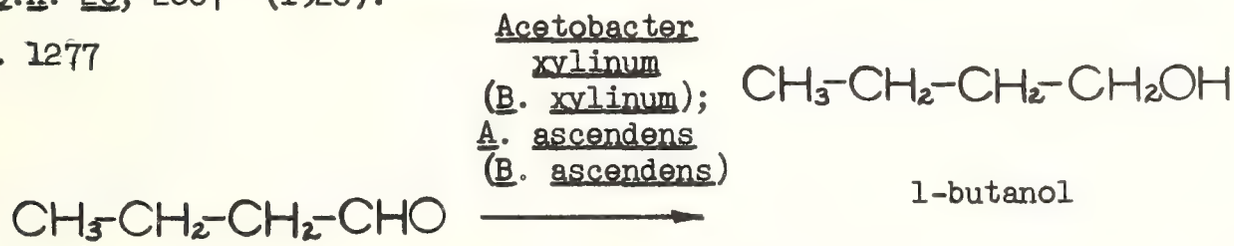


pyruvic acid

acetic acid

Neuberg and Windisch, Biochem. Z. 166, 454-81 (1925).
C.A. 20, 2867[6] (1926).

Rx. 1277

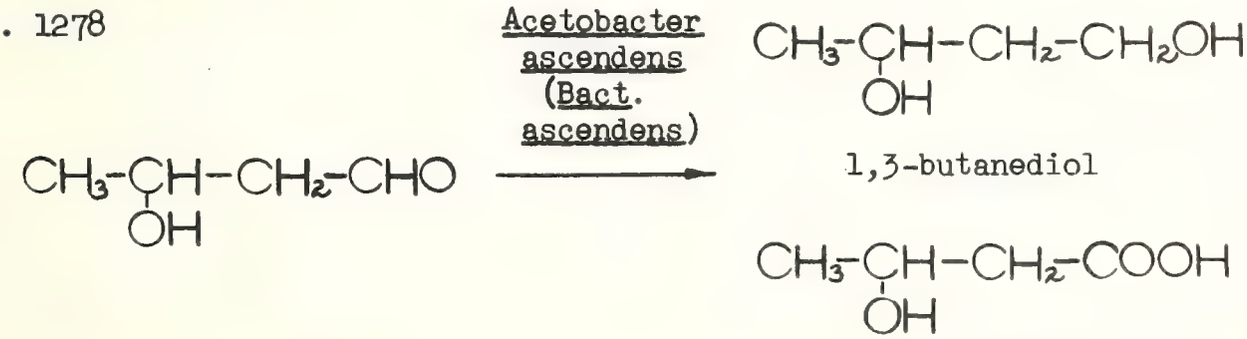


n-butyraldehyde

n-butyric acid

Binder-Kotrba, Biochem. Z. 174, 448-51 (1926).
C.A. 21, 435[2] (1927).

Rx. 1278



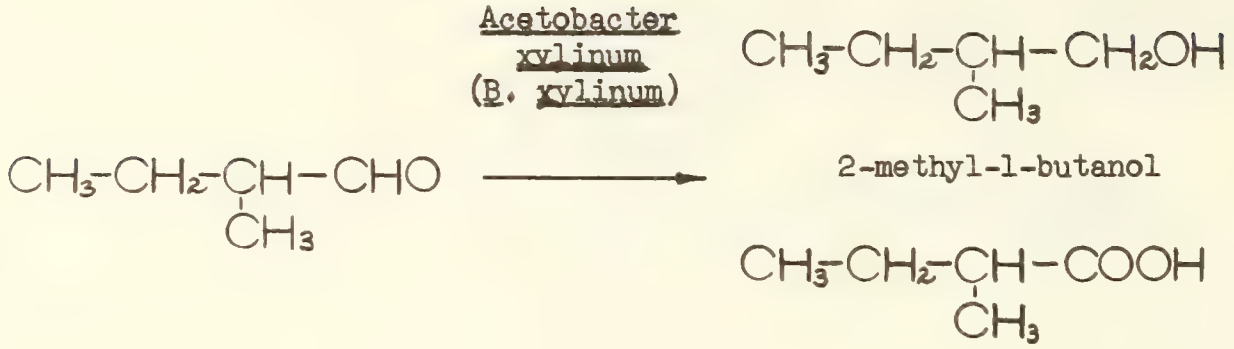
β-hydroxybutyraldehyde
(acetaldol)

β-hydroxybutyric acid

Neuberg and Simon, Biochem. Z. 174, 452-6 (1926).

C.A. 21, 426[3] (1927).

Rx. 1279



2-methylbutyraldehyde

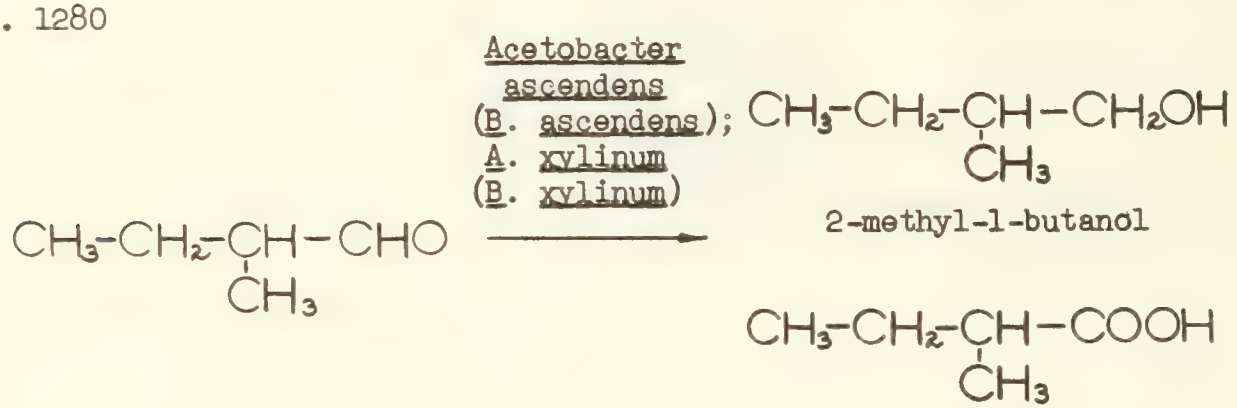
2-methyl-1-butanol

2-methylbutyric acid

Molinari, Biochem. Z. 216, 187-215 (1929). See Neuberg and Simon, ibid. 174, 452-6 (1926).

C.A. 24, 1397[5] (1930).

Rx. 1280



2-methylbutyraldehyde

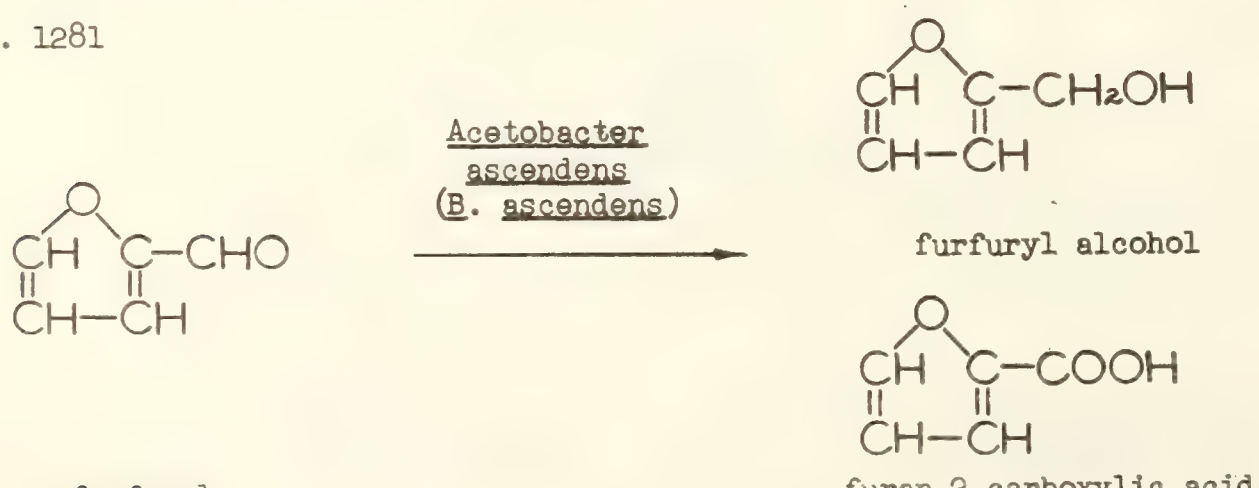
2-methyl-1-butanol

2-methylbutyric acid

Molinari, Biochem. Z. 216, 187-215 (1929).

C.A. 24, 1397[5] (1930).

Rx. 1281



furfural

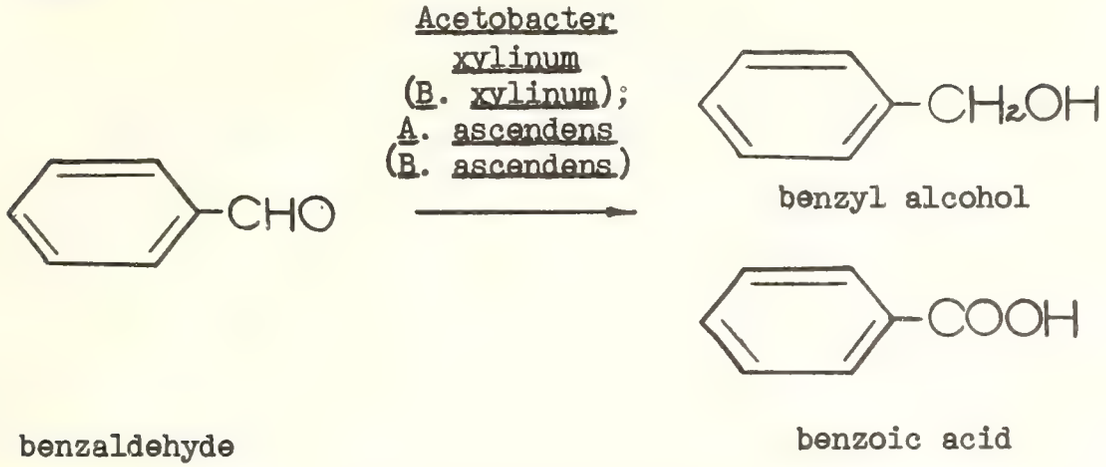
furfuryl alcohol

furan-2-carboxylic acid

Molinari, Biochem. Z. 216, 187-215 (1929).

C.A. 24, 1397[5] (1930).

Rx. 1282



benzaldehyde

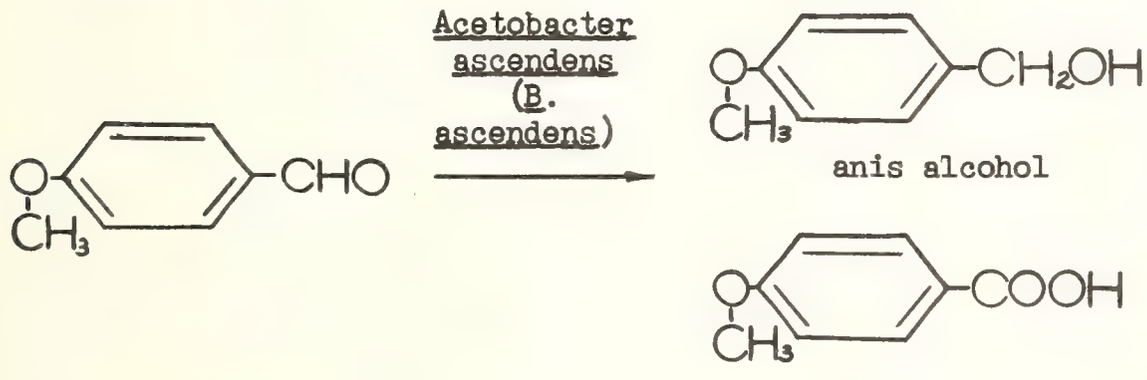
benzyl alcohol

benzoic acid

Molinari, Biochem. Z. 216, 187-215 (1929).

C.A. 24, 1397[5] (1930).

Rx. 1283



anisaldehyde

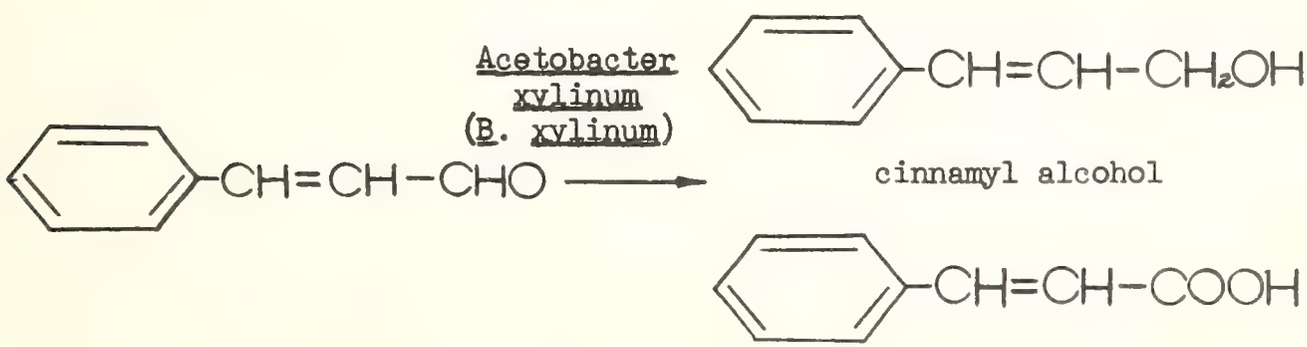
anis alcohol

anisic acid

Molinari, Biochem. Z. 216, 187-215 (1929).

C.A. 24, 1397[5] (1930).

Rx. 1284



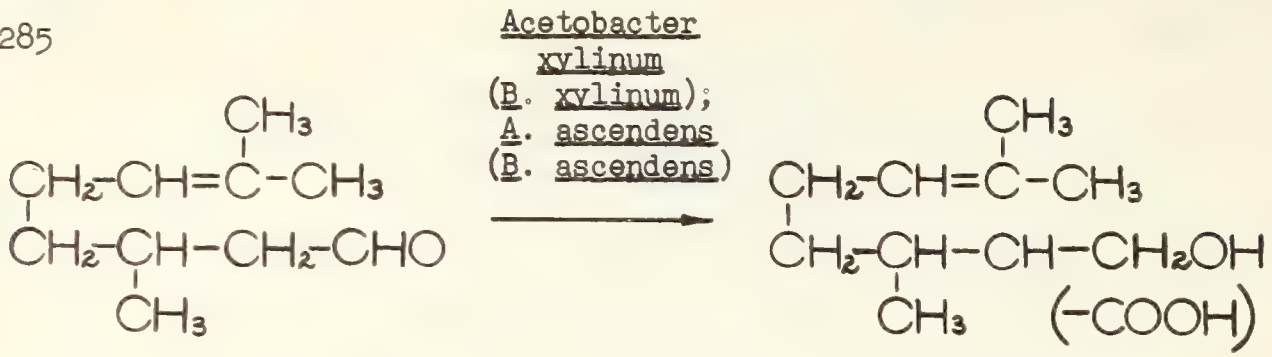
cinnamaldehyde

cinnamyl alcohol

cinnamic acid

Molinari, Biochem. Z. 216, 187-215 (1929).
C.A. 24, 1397[5] (1930).

Rx. 1285

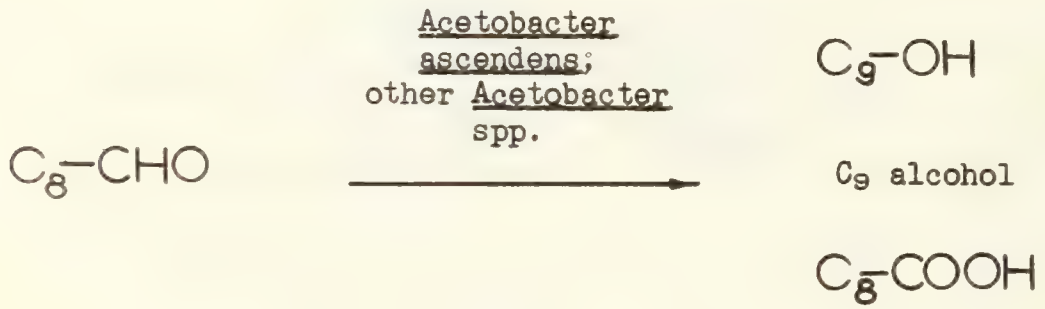


citronellal

citronellol and citronellic acid

Crowe, U.S. 2,743,212 (Apr. 24, 1956).
C.A. 50, 10983a (1956).

Rx. 1286



C_9 aldehyde

C_9 acid

XI. Condensation

a. $-CHO + CH_3-CHO \longrightarrow -CH(OH)-C(=O)-CH_3$

Neuberg and Reinfurth, Biochem. Z. 143, 553-65 (1923).

C.A. 18, 2181[9] (1924).

Rx. 1287

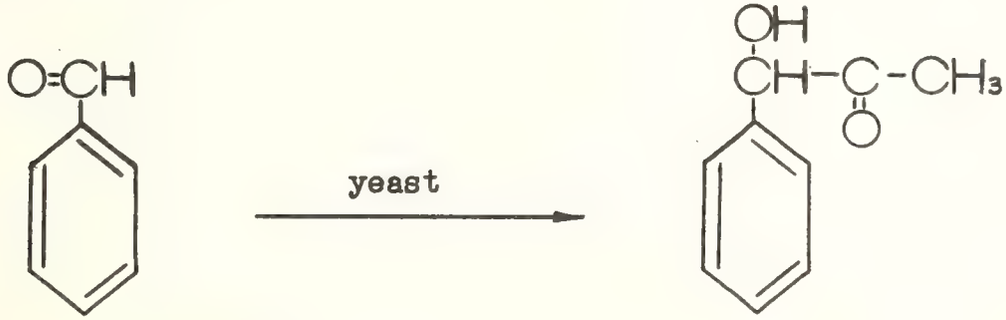
$CH_3-CHO \xrightarrow{\text{top or bottom yeast}} CH_3-CH(OH)-C(=O)-CH_3$

acetaldehyde — acetylmethylcarbinol (3-keto-2-butanol)

Neuberg and Hirsch, Biochem. Z. 115, 282-310 (1921).

C.A. 15, 2105[1] (1921).

Rx. 1288

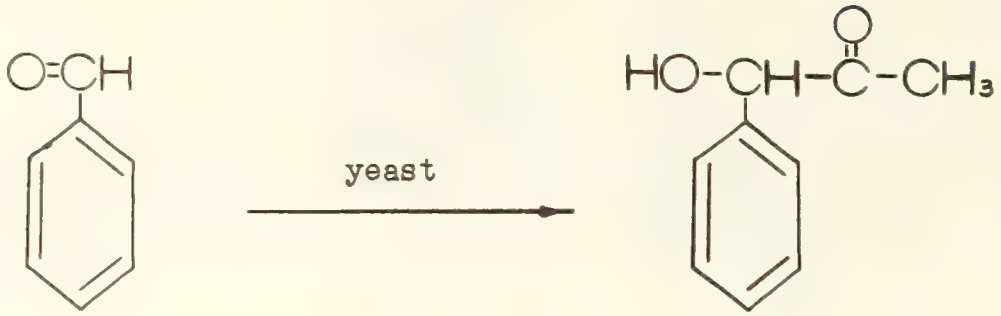


benzaldehyde (plus acetaldehyde) — l-phenylacetylcarbinol

Shimazu, J. Chem. Soc. Japan 71, 503-5 (1950).

C.A. 45, 9004d (1951).

Rx. 1289



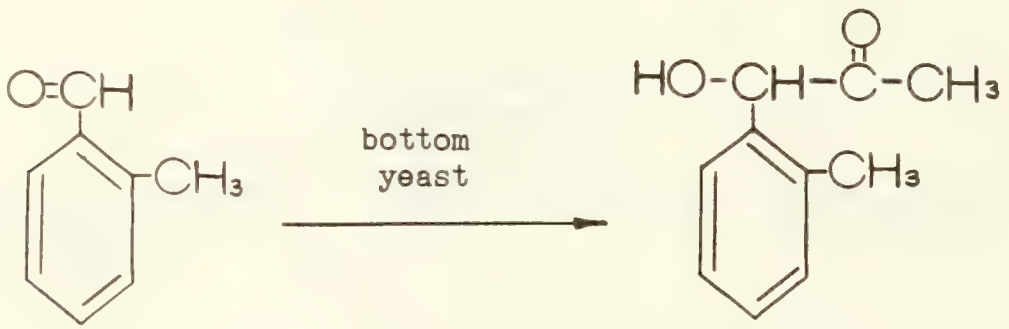
benzaldehyde
(plus pyruvic acid)

phenylacetylcarbinol

Behrens and Iwanoff, Biochem. Z. 169, 478-81 (1926).

C.A. 20, 3303[3] (1926)

Rx. 1290



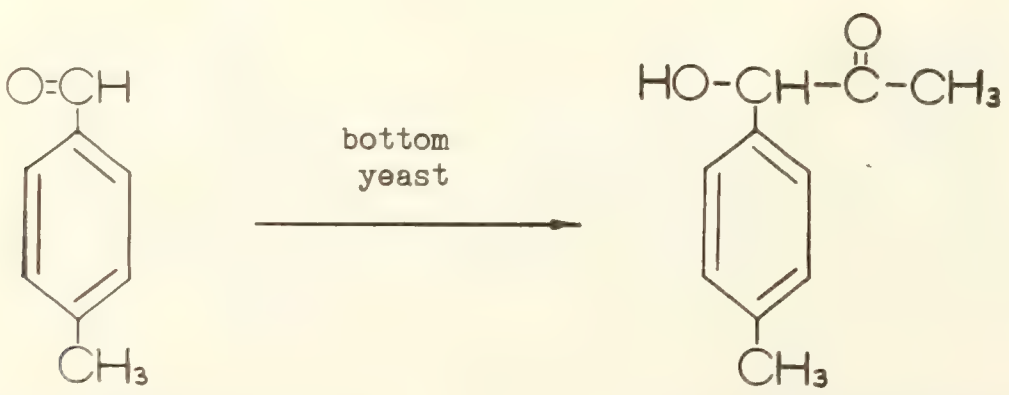
o-tolualdehyde
(plus acetaldehyde)

o-tolylacetylcarbinol

Behrens and Iwanoff, Biochem. Z. 169, 478-81 (1926).

C.A. 20, 3303[3] (1926).

Rx. 1291



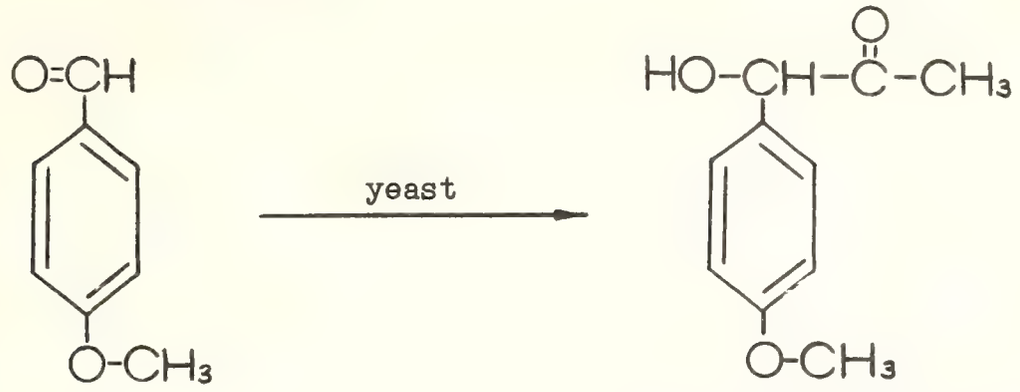
p-tolualdehyde

p-tolylacetylcarbinol

Neuberg and Liebermann, Biochem. Z. 121, 311-25 (1921).

C.A. 16, 108^{9} (1922).

Rx. 1292



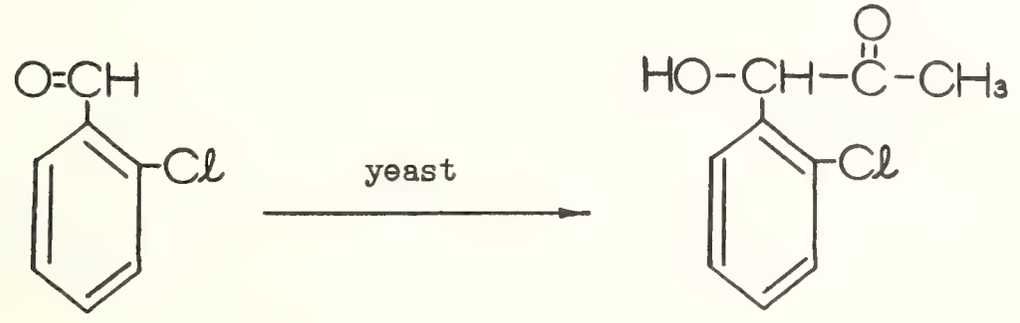
p-anisaldehyde (plus acetaldehyde) (p-methoxybenzaldehyde)

l-p-methoxyphenylacetylcarbinol

Neuberg and Liebermann, Biochem. Z. 121, 311-25 (1921).

C.A. 16, 108^{9} (1922).

Rx. 1293



o-chlorobenzaldehyde

l-o-chlorophenylacetylcarbinol

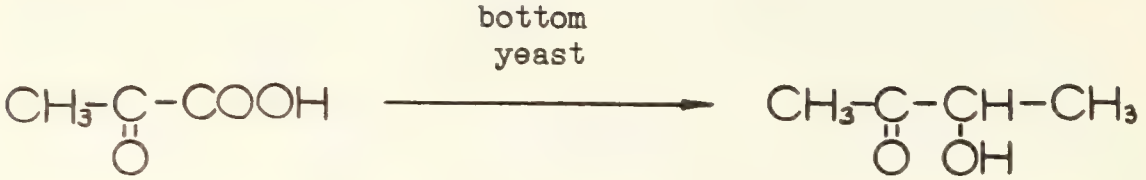
XI. Condensation

b. Miscellaneous types

Neuberg and von May, Biochem. Z. 140, 299-314 (1923).

C.A. 18, 1305[6] (1924).

Rx. 1294

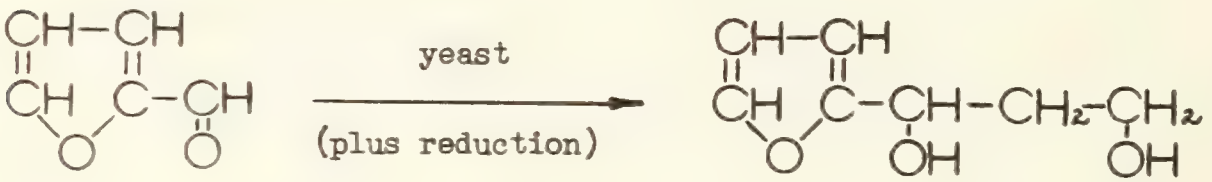


pyruvic acid — acetoin

Lintner and Liebig, Z. physiol. Chem. 88, 109-21 (1913).

C.A. 8, 1126[6] (1914).

Rx. 1295

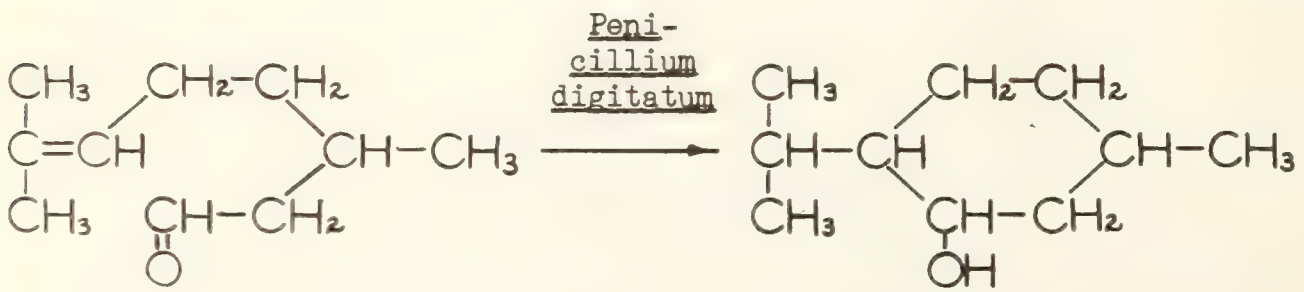


furfural (plus acetaldehyde) — 1-furyltrimethylene glycol

Babička et al., Czech. 84,320 (May 1, 1955).

C.A. 50, 9686b (1956).

Rx. 1296



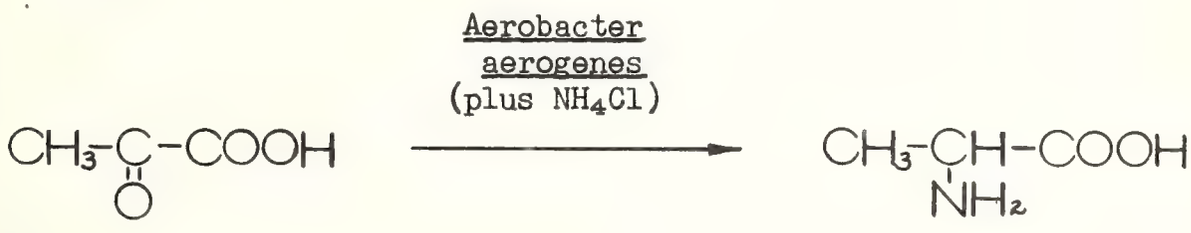
citronellal — menthol (93%)

XII. Amination

a.

Paretsky, Iowa State Coll. J. Sci. 23, 61-3 (1948).

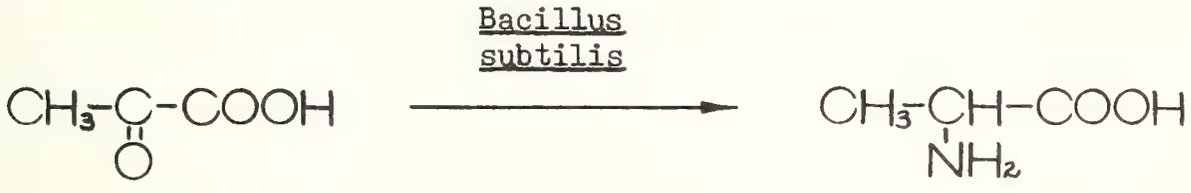
Rx. 1297



pyruvic acid — alanine

Fairhurst et al., J. Gen. Microbiol. 15, 106-20 (1956). See Shah et al., C.A. 50, 16977i (1956). ibid. 17, 620-4 (1957).

Rx. 1298

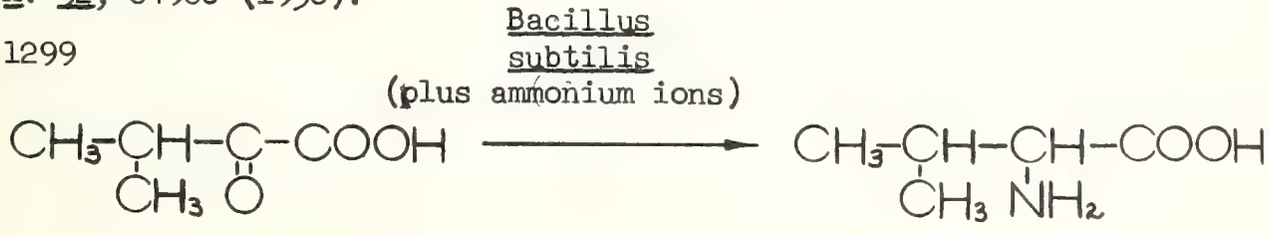


pyruvic acid — alanine

Shah et al., J. Gen. Microbiol. 17, 620-4 (1957).

C.A. 52, 6496e (1958).

Rx. 1299

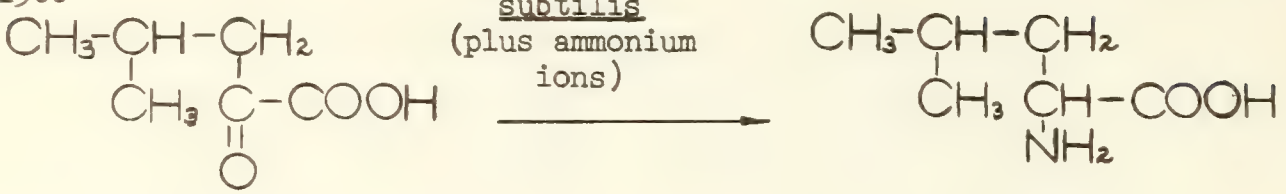


2-keto-3-methylbutyric acid — valine

Shah et al., J. Gen. Microbiol. 17, 620-4 (1957).

C.A. 52, 6496e (1958).

Rx. 1300

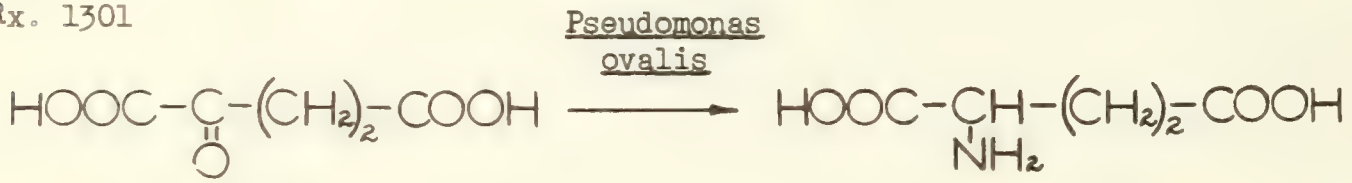


2-keto-4-methyl-valeric acid — leucine

Otsuka et al., Bull. Agr. Chem. Soc. Japan 21, 69-70 (1957).

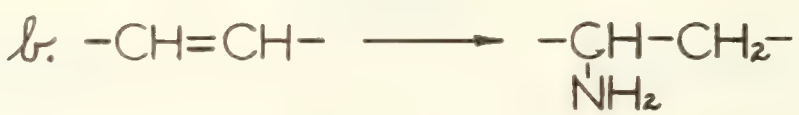
C.A. 51, 10664b (1957).

Rx. 1301



α-ketoglutaric acid — L-glutamic acid (60%)

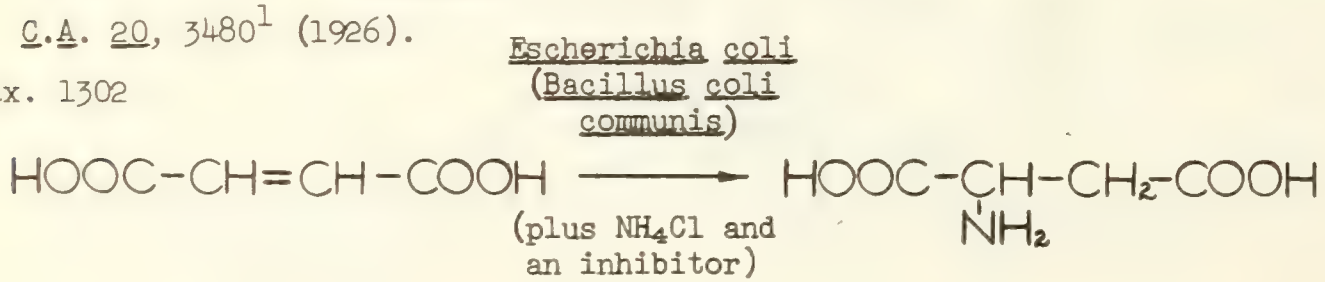
XII. Amination



Quastel and Woolf, Biochem. J. 20, 545-55 (1926).

C.A. 20, 3480[1] (1926).

Rx. 1302

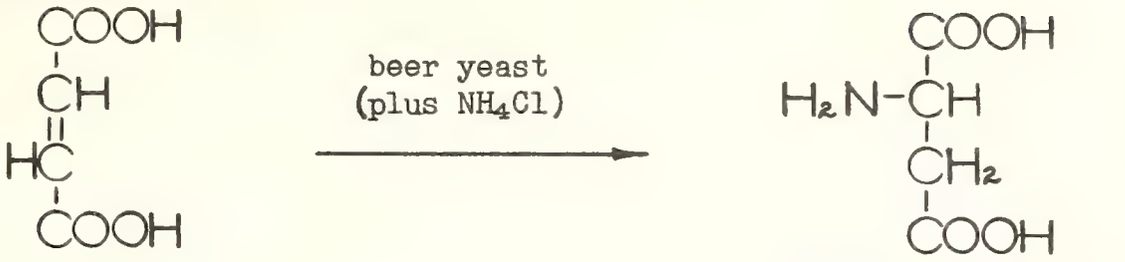


fumaric acid — l-aspartic acid (60%)

Sumiki, Bull. Jap. Soc. Ferment. 23, 33-41 (1928).

C.A. 23, 2531[2] (1929).

Rx. 1303

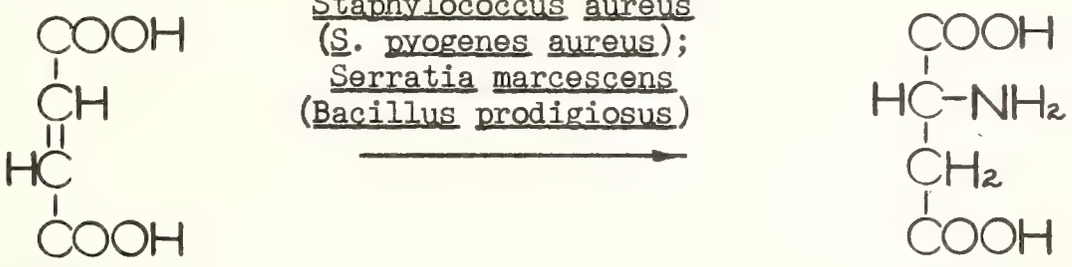


fumaric acid — L-aspartic acid (75%)

Abe, Tohoku J. Exptl. Med. 49, 33-7 (1947).

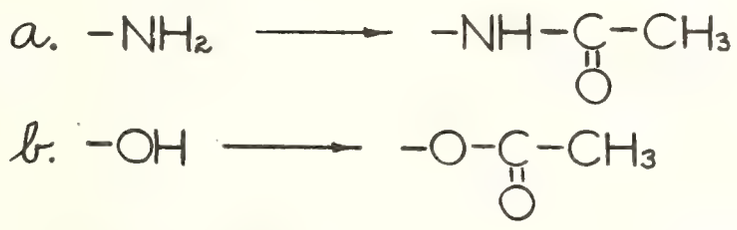
C.A. 44, 3563f (1950).

Rx. 1304



fumaric acid — aspartic acid

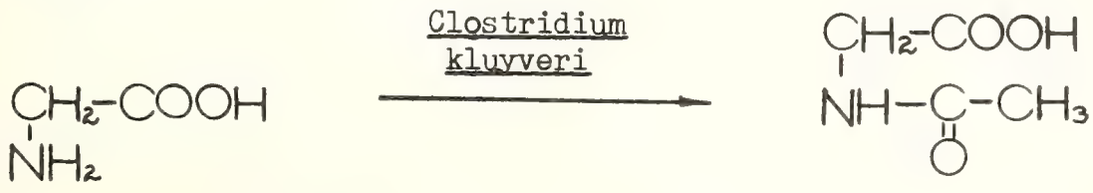
XIII. Acetylation



Katz et al., J. Biol. Chem. 200, 417-29 (1953).

C.A. 47, 3927g (1953).

Rx. 1305

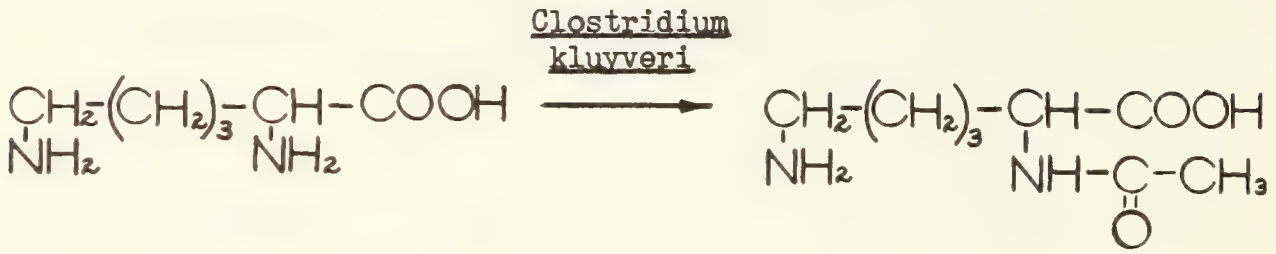


glycine — acetylglycine

Katz et al., J. Biol. Chem. 200, 417-29 (1953).

C.A. 47, 3927g (1953).

Rx. 1306

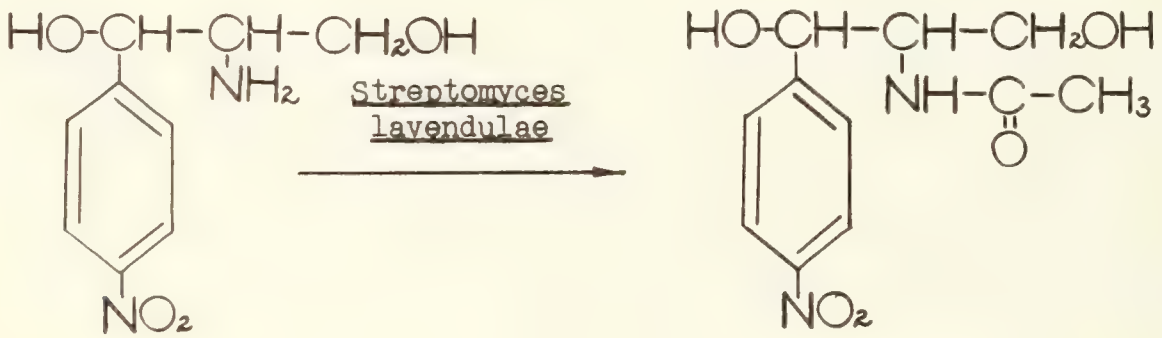


lysine — α-N-acetyllysine

Gottlieb et al., J. Bacteriol. 72, 153-6 (1956).

C.A. 50, 15718f (1956).

Rx. 1307

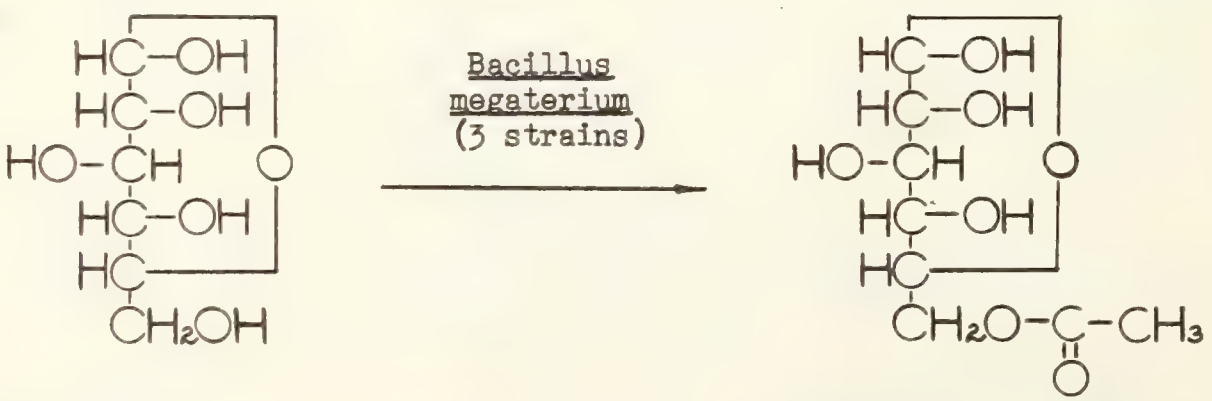


p-nitrophenylserinol — N-acetyl-p-nitrophenylserinol (55%)

Duff et al., Nature 179, 103-4 (1957).

C.A. 51, 12211d (1957).

Rx. 1308



D-glucose — 6-O-acetyl-D-glucose (20%)

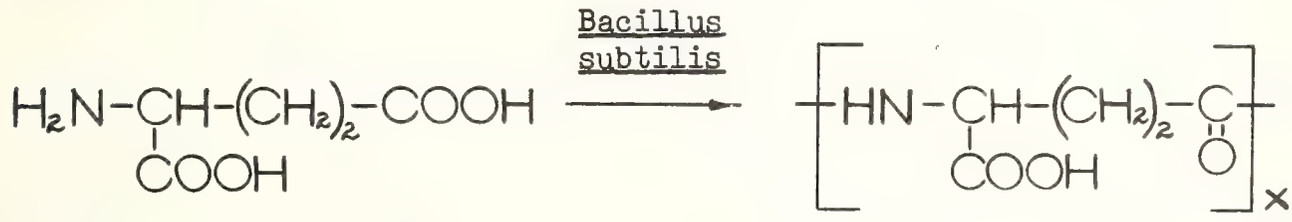
XIV. Amidation

a. $-\overset{\overset{O}{\|}}{C}-OH \longrightarrow -\overset{\overset{O}{\|}}{C}-NH-$

Bovarnick, J. Biol. Chem. 145, 415-24 (1942). See Thorne et al., J. Bacteriol. 68, 307-15 (1954).

C.A. 37, 901^4 (1943).

Rx. 1309



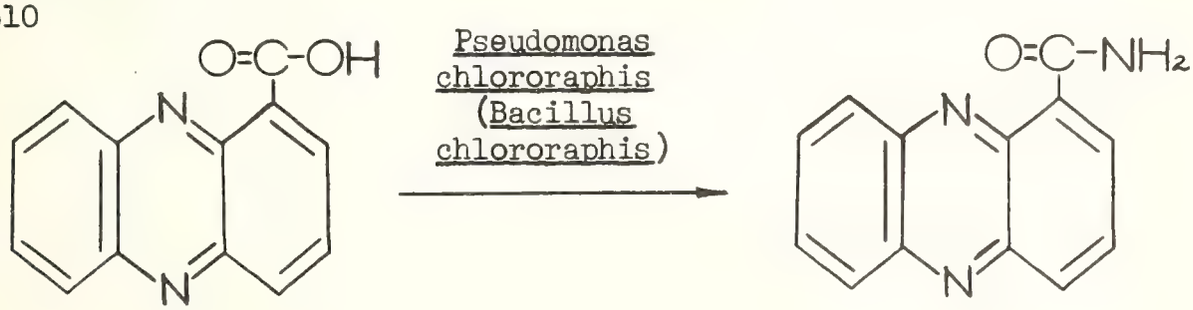
d-(-)-glutamic acid

glutamyl polypeptide

Kögl et al., Ann. 497, 265-89 (1932).

C.A. 26, 5570^3 (1932).

Rx. 1310



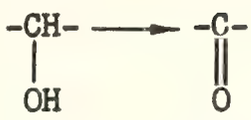
phenazine-α-carboxylic acid (K salt)

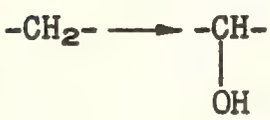
phenazine-α-carboxamide

TYPE REACTION INDEX

Rx. Nos.

I. OXIDATION

a.  1-151

b.  152-286

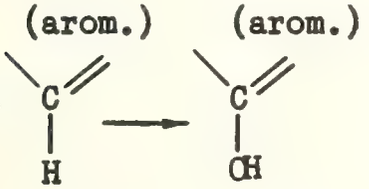
c. -CHO ⟶ -COOH 287-361

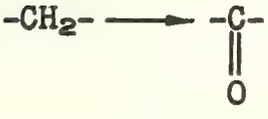
d. $-CH_2-CH_2- \longrightarrow -CH{=}CH-$ 362-425

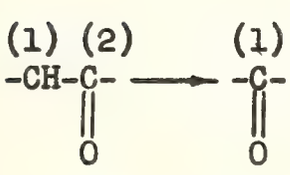
e. $-CH_2OH \longrightarrow -COOH$ 426-456

f. 457-486

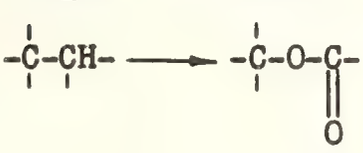
g. $-CH_3 \longrightarrow -CH_2OH$ 487-507

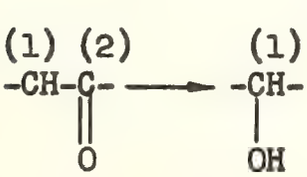
h.  508-524

i.  525-542

j.  543-557

k. $-CH_2OH \longrightarrow -CHO$ 558-567

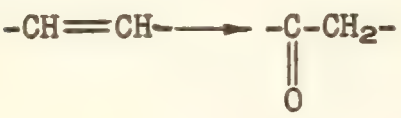
l.  568-575

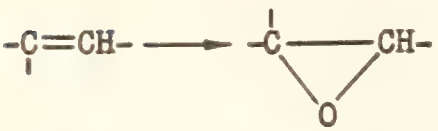
m.  576-584

n. 585-590

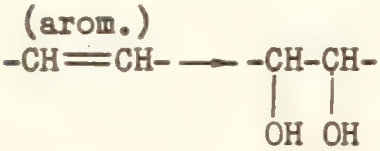
Rx. Nos.

I. OXIDATION - continued

o.  591-595

p.  596-599

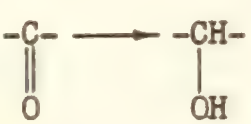
q. 600-602

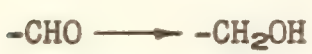
r.  603-605

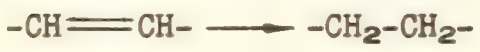
s. 606-608

t. Miscellaneous types 609-628

II. REDUCTION

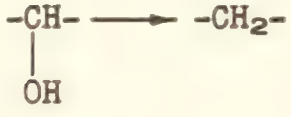
a.  629-738

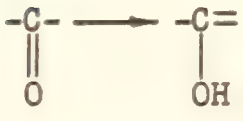
b.  739-783

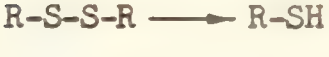
c.  784-810

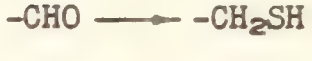
d. 811-831

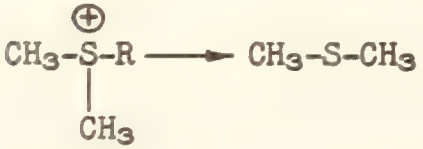
e. 832-850

f.  851-862

g.  863-872

h.  873-879

i.  880-883

j.  884-887

		Rx. Nos.
II.	REDUCTION--continued	
	k. $-CH_2OH \longrightarrow -CH_3$	888-890
	l. Reduction to methane	891-898
	m. Miscellaneous types	899-928
III.	DECARBOXYLATION	
	a. $-CH_2-COOH \longrightarrow -CH_3$	929-950
	b. $-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH \longrightarrow -\underset{\displaystyle NH_2}{\underset{|}{CH_2}}$	951-972
	c. $-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH \longrightarrow -\underset{\displaystyle OH}{\underset{|}{CH_2}}$	973-985
	d. $-\overset{(1)(2)}{\underset{\displaystyle O}{\underset{\|\|}{C}}}-COOH \longrightarrow \overset{(1)}{-COOH}$	986-994
	e. $-\overset{(1)(2)}{\underset{\displaystyle O}{\underset{\|\|}{C}}}-COOH \longrightarrow \overset{(1)}{-CHO}$	995-1001
	f. $-\overset{(1)(2)}{\underset{\displaystyle O}{\underset{\|\|}{C}}}-COOH \longrightarrow \overset{(1)}{-CH_2OH}$	1002-1005
	g. $-\overset{(1)\ (2)}{\underset{\displaystyle NH_2}{\underset{|}{CH}}}-COOH \longrightarrow \overset{(1)}{-COOH}$	1006-1008
	h. Miscellaneous types	1009-1020
IV.	DEAMINATION	
	a. $-\underset{\displaystyle NH_2}{\underset{|}{CH}}- \longrightarrow -\underset{\displaystyle OH}{\underset{|}{CH}}-$	1021-1050
	b. $-\underset{\displaystyle NH_2}{\underset{|}{CH}}- \longrightarrow -CH_2-$	1051-1068

Rx. Nos.

IV. DEAMINATION--continued

c. $-\overset{|}{\underset{NH_2}{C}}H- \longrightarrow -\overset{\|}{\underset{O}{C}}-$ 1069-1083

d. $-\overset{|}{\underset{NH_2}{C}}H- \longrightarrow -COOH$ 1084-1089

e. $-\overset{|}{\underset{NH_2}{C}}H- \longrightarrow -\overset{|}{\underset{OH}{C}}H_2$ 1090-1094

f. $-CH_2-\overset{|}{\underset{NH_2}{C}}H- \longrightarrow -CH{=}{=}CH-$ 1095-1098

g. Miscellaneous types 1099-1104

V. GLYCOSYLATION

Miscellaneous types 1105-1163

$$n\ R(OH)_2 \longrightarrow \left[R\text{-}O\right]_n$$

[$R(OH)_2$ = carbohydrate moiety]

$$R\text{-}O\text{-}R + R'\text{-}(OH)_2 \longrightarrow R\text{-}O\text{-}R' + R(OH)_2$$

(OH, OH) (OH, OH)

VI. HYDROLYSIS

a. $H\overset{|}{C}\text{-}O\text{-}\overset{|}{C}H + H_2O \longrightarrow H\overset{|}{C}\text{-}OH + HO\text{-}\overset{|}{C}H$ 1164-1177

b. $R\text{-}COOR' + H_2O \longrightarrow R'OH + R\text{-}COOH$ 1178-1183

c. $\overset{(arom.)}{=\overset{|}{C}}\text{-}O\text{-}\overset{|}{C}H + H_2O \longrightarrow \overset{(arom.)}{=\overset{|}{C}}\text{-}OH + HO\text{-}CH\text{-}$ 1184-1188

d. Proteins and amino acids 1189-1191

e. $-NH\text{-}\overset{|}{C}\text{-} + H_2O \longrightarrow -NH_2 + HO\text{-}\overset{|}{C}\text{-}$ 1192-1198

f. $-\overset{\|}{\underset{NH}{C}}- + H_2O \longrightarrow -\overset{\|}{\underset{O}{C}}-$ 1199-1202

g. Miscellaneous types 1203-1206

		Rx. Nos.
VII.	ALKYLATION (METHYLATION)	
	a. $SeO_3^{=}{}_{(4)} \longrightarrow CH_3\text{-}Se\text{-}CH_3$	1207-1213
	b. $R\text{-}S\text{-}S\text{-}R \longrightarrow R\text{-}S\text{-}CH_3$	1214-1218
	c. $R\underset{\underset{O}{\|}}{As}(OH)_2 \longrightarrow R\text{-}As\text{-}(CH_3)_2$	1219-1223
	d. $R_2\underset{\underset{O}{\|}}{As}\text{-}OH \longrightarrow R_2As\text{-}CH_3$	1224-1227
	e. Miscellaneous types	1228-1238
VIII.	ESTERIFICATION	
	a. $ROH + H_3PO_4 \longrightarrow RO\text{-}PO_3H_2$	1239-1249
	b. $ROH + -COOH \longrightarrow -COOR$	1250-1258
	c. Miscellaneous types	1259
IX.	DEHYDRATION	
	a. $-CH\text{-}\overset{\overset{OH}{\|}}{C}- \longrightarrow -C{=}C-$	1260-1265
	b. $-CH_2\text{-}\underset{\underset{OH}{\|}}{CH}- \longrightarrow -CH{=}CH-$	1266-1270
	c. Miscellaneous types	1271-1273
X.	ASYMMETRIC DISMUTATION	
	$-CHO \longrightarrow -CH_2OH + -COOH$	1274-1286
XI.	CONDENSATION	
	a. $-CHO + CH_3\text{-}CHO \longrightarrow -\underset{\underset{OH}{\|}}{CH}\text{-}\underset{\underset{O}{\|}}{C}\text{-}CH_3$	1287-1293
	b. Miscellaneous types	1294-1296

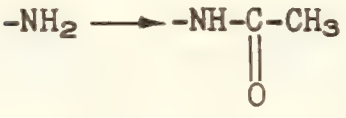
Rx. Nos.

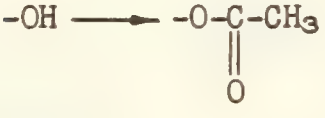
XII. AMINATION

a. 1297-1301

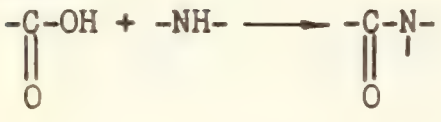
b. 1302-1304

XIII. ACETYLATION

a.  1305-1307

b.  1308

XIV. AMIDATION

 1309-1310

MICROORGANISM INDEX

		Rx. Nos.
1.	Absidia species	1080
2.	Acetic acid bacteria	70
3.	Acetobacter aceti	5, 20, 21, 44, 45, 48, 56, 308, 310, 427, 434, 439, 441, 443, 1007, 1085
4.	Acetobacter aceticum	333
5.	Acetobacter acetigenum (re-named A. acetigenus)	63, 343, 1119, 1120
6.	Acetobacter acetosum	71, 292, 441
7.	Acetobacter acetovorum	14, 57, 339
8.	Acetobacter acidum-mucosum (same as A. pasteurianus)	438
9.	Acetobacter ascendens	324, 434, 441, 671, 755, 1274, 1276, 1277, 1278, 1280, 1281, 1282, 1283, 1285, 1286
10.	Acetobacter capsulatum	13, 1161, 1162
11.	Acetobacter gluconicum	54, 65, 75, 305, 345, 565, 621, 1265
12.	Acetobacter kützingianum (re-named A. kuetzingianus)	50, 312, 428, 440, 444, 448, 450
13.	Acetobacter melanogenum (re-named A. melanogenus)	57, 72, 99, 100, 295, 302, 333, 350, 360, 361
14.	Acetobacter mobile	65, 345
15.	Acetobacter orleanense	63, 71, 343
16.	Acetobacter pasteurianum (re-named A. pasteurianus)	2, 63, 312, 343, 428, 432, 440, 444, 448, 450, 754, 1276
17.	Acetobacter peroxydans	56
18.	Acetobacter rancens	1026, 1046, 1065
19.	Acetobacter roseus	321, 454, 567
20.	Acetobacter schützenbachii (same as A. schuetzenbachii)	1065, 1085, 1099

		Rx. Nos.
21.	Acetobacter species	1, 13, 65, 71, 76, 90, 292, 308, 324, 333, 345, 445, 1286
22.	Acetobacter suboxydans	7, 10, 22, 25, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 46, 52, 55, 58, 68, 76, 84, 93, 95, 97, 289, 302, 330, 348, 432, 1273
23.	Acetobacter suboxydans muciparum (believed physiologically identical to A. suboxydans)	82, 295, 302
24.	Acetobacter turbidans	63, 71, 343, 436
25.	Acetobacter viscosum	1162
26.	Acetobacter xylinum	4, 9, 12, 20, 23, 34, 44, 45, 47, 48, 53, 56, 65, 69, 81, 91, 92, 94, 96, 291, 298, 307, 311, 345, 558, 565, 991, 1105, 1125, 1275, 1276, 1277, 1279, 1280, 1282, 1284, 1285
27.	Actinomyces No. 1164	139, 212, 585, 826
28.	Achromobacter species	1180
29.	Aerobacter aerogenes	64, 74, 90, 296, 303, 306, 309, 344, 352, 636, 673, 752, 959, 970, 983, 984, 1009, 1040, 1041, 1089, 1274, 1297
30.	Aerobacter cloacae	1245
31.	Aerobacter levanicum	1141, 1143
32.	Aerobacter species	90, 855
33.	Aerobic bacteria	102
34.	Aerobic organisms	426
35.	Aeromonas specie	1134
36.	Agrobacterium tumefaciens	1132
37.	Alcaligenes faecalis	108, 133, 134, 135, 136, 137
38.	Alcaligenes species	403, 728, 1180

		Rx. Nos.
39.	Alginomonas species	1171
40.	Anaerobic bacteria	891, 893, 895, 896, 897, 1068
41.	Aspergillus chevalieri	552, 553, 580, 582
42.	Aspergillus cinnamomeus	315, 316
43.	Aspergillus clavatus	285
44.	Aspergillus elegans	765
45.	Aspergillus fischeri	285
46.	Aspergillus flavus	546, 569, 575
47.	Aspergillus fumigatus	244
48.	Aspergillus fuscus	315
49.	Aspergillus gallomyces	1185
50.	Aspergillus glaucus	319, 1223, 1237
51.	Aspergillus itaconicus	194
52.	Aspergillus japonicus	316
53.	Aspergillus nidulans	223, 267, 285, 765
54.	Aspergillus niger	6, 29, 126, 153, 155, 163, 178, 181, 186, 193, 217, 228, 232, 238, 266, 314, 315, 340, 452, 487, 488, 492, 501, 502, 503, 504, 506, 510, 511, 512, 513, 514, 515, 516, 517, 521, 522, 523, 524, 525, 610, 611, 613, 615, 824, 930, 936, 1017, 1018, 1082, 1103, 1107, 1111, 1131, 1135, 1136, 1184, 1185, 1187, 1190, 1209, 1213, 1223, 1240, 1263, 1264
55.	Aspergillus ochraceus	185, 198, 240, 269
56.	Aspergillus oryzae	327, 552, 553, 571, 580, 582, 1017, 1073, 1074, 1079, 1163, 1187, 1263, 1264
57.	Aspergillus species	194, 200, 204, 495, 527, 528, 529, 531, 533, 534, 556, 557, 764, 765, 939, 940, 944, 1080, 1111

		Rx. Nos.
58.	Aspergillus tamarii	527, 529, 531, 534, 939, 941, 943, 945
59.	Aspergillus terreus	186, 1176
60.	Aspergillus ustus	285
61.	Aspergillus wentii	194, 325, 766
62.	Azotobacter oxydans	590
63.	Azotobacter species	148, 590
64.	B. coli (same as Escherichia coli)	958, 1070, 1071, 1072, 1089, 1274
65.	Bacillus amaracrylus	1267
66.	Bacillus aminophilus intestinalis (probably a variety of Klebsiella pneumoniae)	962, 967
67.	Bacillus amylobacter (same as Clostridium butyricum)	1166
68.	Bacillus butylicus (same as Clostridium butyricum)	1013
69.	Bacillus carotovorus (same as Erwinia carotovora)	437
70.	Bacillus cereus	466, 1133
71.	Bacillus chlororaphis (same as Pseudomonas chlororaphis)	1310
72.	Bacillus cloacae (same as Aerobacter cloacae)	1009
73.	Bacillus coli (same as Escherichia coli)	736, 789
74.	Bacillus coli communis (same as Escherichia coli)	732, 734, 735, 911, 963, 1054, 1097, 1302
75.	Bacillus delbrükii (same as Lactobacillus delbrueckii)	674
76.	Bacillus fluorescens liquefaciens (same as Pseudomonas fluorescens)	791, 807, 958, 1270

		Rx. Nos.
77.	Bacillus fluorescens non liquefaciens (same as Pseudomonas eisenbergii)	1262
78.	Bacillus lactis (possibly Bacillus cereus)	1133
79.	Bacillus lactis aerogenes (same as Aerobacter aerogenes	636, 673, 959, 984, 1009, 1040, 1041
80.	Bacillus levaniformans (possibly a variety of Bacillus vulgatus)	1137
81.	Bacillus liquefaciens magnus (probably Clostridium bifermentans)	1067
82.	Bacillus macerans	1164, 1165, 1177
83.	Bacillus megaterium	649, 1057, 1256, 1258, 1308
84.	Bacillus megatherium (same as Bacillus megaterium)	1256, 1258
85.	Bacillus mesentericus (possibly Bacillus subtilis)	970, 984, 1139, 1160
86.	Bacillus polymyxa	1141, 1143, 1172, 1267
87.	Bacillus praepollens (Species incertae sedis)	1254
88.	Bacillus prodigiosus (same as Serratia marcescens)	1304
89.	Bacillus proteus vulgaris (same as Proteus vulgaris)	966, 1033
90.	Bacillus putrificus (same as Clostridium lentoputrescens)	702, 707, 711, 712, 713, 714, 815, 816, 817, 819, 820, 825, 888, 1051, 1053, 1064, 1066
91.	Bacillus pyocyaneus (same as Pseudomonas aeruginosa)	287, 455, 1015, 1186
92.	Bacillus saccharobutyricus liquefaciens (same as Clostridium acetobutylicum)	1166
93.	Bacillus sphaericus	365, 380, 389, 395, 398, 404, 420
94.	Bacillus spinosus	1067

		Rx. Nos.
95.	Bacillus subtilis	98, 400, 407, 415, 649, 791, 847, 966, 970, 984, 1025, 1032, 1044, 1057, 1139, 1141, 1160, 1198, 1298, 1299, 1300, 1309
96.	Bacillus typhosus (same as Salmonella typhosa)	1097
97.	Bacillus vulgatus	1137
98.	Bacillus welchii (same as Clostridium perfringens)	1268
99.	Bacteria	103, 122, 124, 144, 349, 355, 431, 442, 451, 588, 603, 612, 614, 705, 706, 708, 709, 800, 810, 818, 830, 852, 862, 866, 889, 908, 909, 933, 934, 951, 952, 954, 955, 957, 960, 961, 971, 972, 986, 988, 990, 993, 1009, 1010, 1026, 1052, 1056, 1057, 1058, 1059, 1060, 1063, 1069, 1086, 1087, 1100, 1102, 1167, 1189, 1192, 1193, 1194, 1197, 1199, 1266, 1271
100.	Bacterium aceti (same as Acetobacter aceti)	48, 434, 443, 1007, 1085
101.	Bacterium acetigenoideum	433
102.	Bacterium anitratum	358
103.	Bacterium ascendens (same as Acetobacter ascendens)	434, 671, 1274, 1276, 1277, 1278, 1280, 1281, 1282, 1283, 1285
104.	Bacterium coli (same as Escherichia coli)	635, 659, 752, 786, 791, 807, 890, 901, 984
105.	Bacterium coli commune (same as Escherichia coli)	968
106.	Bacterium dihydroxyacetonicum (Nomen nudem)	11
107.	Bacterium eucalypti (Nomen nudem)	1138, 1159
108.	Bacterium freundii (same as Escherichia freundii)	659, 853

		Rx. Nos.
109.	Bacterium gluconicum (same as Acetobacter gluconicus)	75, 305, 565, 621, 1265
110.	Bacterium hoshigaki var. glucuronicum II	328, 329
111.	Bacterium hoshigaki var. rosea (same as Acetobacter roseus)	321
112.	Bacterium industrium var. hoshigaki	323, 454
113.	Bacterium kützingianum (same as Acetobacter kuetzingianus)	312, 428, 440, 444, 448, 450
114.	Bacterium lactis aerogenes (same as Aerobacter aerogenes)	752, 970, 983, 1089, 1274
115.	Bacterium oblongum	67
116.	Bacterium oblongus (same as Micrococcus oblongus)	347
117.	Bacterium pasteurianum (same as Acetobacter pasteurianus)	312, 428, 432, 440, 444, 448, 450, 754
118.	Bacterium putidum (same as Pseudomonas putida)	331
119.	Bacterium rancens (same as Acetobacter rancens)	1026, 1046, 1065
120.	Bacterium savastanoi (same as Pseudomonas savastanoi)	313
121.	Bacterium schützenbachii (same as Acetobacter schuetzenbachii)	1007, 1026, 1065, 1085, 1099
122.	Bacterium suboxydans (same as Acetobacter suboxydans)	330
123.	Bacterium succinicum (may belong to the genus Escherichia)	788, 858, 861
124.	Bacterium termo	446
125.	Bacterium xylinoides	54, 1026, 1034, 1037, 1046, 1065, 1099
126.	Bacterium xylinum (same as Acetobacter xylinum)	49, 53, 69, 92, 311, 565, 991, 1105, 1275, 1276, 1277, 1279, 1280, 1282, 1284, 1285

		Rx. Nos.
127.	Betabacterium vermiforme (same as Lactobacillus brevis)	1150
128.	Betacoccus arabinosaceous (same as Leuconostoc mesenteroides)	1124, 1129, 1130
129.	Calonectria decora	378, 379, 390, 396, 545
130.	Candida lipolytica	616
131.	Cephalosporium subverticillatum	547, 570
132.	Cephalothecium roseum	131, 202, 236, 242, 279, 462, 468, 471, 477, 478, 482, 483, 484
133.	Chromobacterium violaceum	520
134.	Citrobacter species (same as Escherichia species)	854
135.	Cladosporium species	1187
136.	Clastosporium species	766
137.	Clostridium acetobutylicum	743, 899, 931, 987, 1166
138.	Clostridium bifermentans	1067
139.	Clostridium butylicum	629, 643, 739, 900, 1013, 1166
140.	Clostridium kluyveri	787, 1305, 1306
141.	Clostridium lentoputrescens	702, 707, 711, 712, 713, 714, 815, 816, 817, 819, 820, 825, 888, 1051, 1053, 1064, 1066
142.	Clostridium perfringens	1195, 1201, 1268
143.	Clostridium propionicum	856
144.	Clostridium sporogenes	1057
145.	Clostridium tertium	1057
146.	Colletotrichum antirrhini	207
147.	Colletotrichum phomoides	247, 278
148.	Colletotrichum pisi	247, 278
149.	Coniothyrium helleborine	247, 278

		Rx. Nos.
150.	Coniothyrium species	274
151.	Corynebacterium mediolanum	132
152.	Corynebacterium simplex	402, 403, 406, 728
153.	Cunninghamella blakesleeana	246, 256, 271, 476, 541, 596, 598
154.	Curvularia falcata	279, 685
155.	Curvularia fallax	237
156.	Curvularia lunata	205, 206, 230, 231, 245, 257, 273, 280, 283, 470, 481, 496, 576, 596, 597, 598, 599, 725, 729
157.	Curvularia pallescens	237, 273, 472
158.	Curvularia species	237
159.	Cyanococcus chromospirans	78, 86
160.	Cylindrocarpon radicola	368, 382, 397, 573
161.	Dactylium dendroides	197, 203, 229, 241, 268, 463
162.	Debaromyces species	1075
163.	Desulfovibrio desulfuricans	859
164.	Didymella lycopersici	369, 370, 371, 408, 411, 423, 424, 425
165.	Didymella vodakii	252
166.	Dothichiza species	275
167.	Eberthella typhosa (same as Salmonella typhosa)	1096
168.	Epicoccum oryzae	727
169.	Erwinia carotovora	437, 1178
170.	Escherichia coli	98, 542, 635, 659, 732, 734, 735, 736, 752, 786, 789, 791, 807, 836, 837, 838, 839, 840, 841, 842, 843, 844, 846, 847, 848, 849, 850, 866, 890, 901, 911, 958, 963, 964, 968, 984, 1054, 1070, 1071, 1072, 1089, 1096, 1097, 1155, 1191, 1198, 1204, 1274, 1302

		Rx. Nos.
171.	Escherichia coli var. communior (same as Escherichia coli)	1155
172.	Escherichia coli indologenes (Nomen dubium)	922, 923
173.	Escherichia freundii	659, 853
174.	Escherichia species	788, 854
175.	Eurotium chevalieri	199
176.	Flavobacterium androstenedionicum	118
177.	Flavobacterium carbonilicum	106, 119, 120
178.	Flavobacterium dehydrogenans	104, 111, 116, 117, 123, 125, 146
179.	Flavobacterium maris	150
180.	Fumago vagans	325, 1109
181.	Fusarium caucasicum	109, 127, 367, 374, 384, 388, 543, 550, 555
182.	Fusarium culmorum	209
183.	Fusarium lini	8, 17, 19, 24, 559, 560, 562
184.	Fusarium lycopersici	209
185.	Fusarium solani	109, 127, 209, 364, 367, 374, 377, 381, 383, 384, 388, 399, 404, 410, 543, 548, 550, 555, 572, 730
186.	Fusarium species	101, 169, 300, 391, 574
187.	Geotrichum candidum	680, 980, 1008, 1029, 1031, 1041, 1043, 1047, 1061, 1078, 1093, 1094, 1104
188.	Geotrichum species	1080
189.	Gibberella baccata	248
190.	Gibberella species	248
191.	Gliocladium catenulatum	179, 546, 549

		Rx. Nos.
192.	Gluconobacter strain	337
193.	Gluconoacetobacter opacus	334
194.	Gluconoacetobacter roseus (probably Acetobacter roseus)	567
195.	Hansenula anomala	558, 561, 564, 1090, 1094, 1103, 1104, 1252, 1253
196.	Hansenula species	1075
197.	Helicostylum piriforme	261, 265, 465, 475, 479, 480, 598
198.	Helminthosporium geniculatum	766
199.	Hormodendrum viride	281
200.	Hydrogenomonas carboxydovorans	609
201.	Klebsiella pneumoniae	962, 967
202.	Lactobacillus acidophilus	863
203.	Lactobacillus bifidus var. pennsylvanicus	1128
204.	Lactobacillus brevis	1150
205.	Lactobacillus bulgaricus	863
206.	Lactobacillus casei	1066
207.	Lactobacillus delbrueckii	674
208.	Lactobacillus leichmannii	863
209.	Lactobacillus species	660, 1269
210.	Lenzites abietina	235, 249
211.	Lenzites species	249
212.	Leuconostocs	640, 642, 660
213.	Leuconostoc dextranicum	1149
214.	Leuconostoc mesenteroides	661, 1124, 1129, 1130, 1148, 1154, 1156, 1157
215.	Methanobacterium formicicum	892. 898

		Rx. Nos.
216.	Methanobacterium omelianskii	435, 449, 894
217.	Methanococcus species	1010
218.	Methanosarcina barkerii	892
219.	Micrococcus calco-aceticus (same as Pseudomonas calco-acetica)	1262
220.	Micrococcus chinicus (Species incertae sedis)	1261
221.	Micrococcus dehydrogenans (same as Flavobacterium dehydrogenans)	104, 111, 116, 117, 123, 125, 146
222.	Micrococcus oblongus	347
223.	Micrococcus pyogenes var. aureus (same as Staphylococcus aureus)	1196, 1202
224.	Microorganisms	429, 595, 829, 831, 978, 1146, 1168, 1179
225.	Molds	1080, 1174, 1200
226.	Moraxella lwoffi	935
227.	Mucor corymbifer	187
228.	Mucor griseocyanus	457, 460, 464, 465, 475, 486
229.	Mucor parasiticus (same as Parasitella simplex	464, 465, 473
230.	Mucor racemosus	1017, 1263, 1264
231.	Mucor rouxii	15
232.	Mucor species	459, 598, 1080
233.	Mycobacterium lacticola	403, 422, 485, 728, 1182, 1183
234.	Mycobacterium phlei	1057
235.	Mycobacterium rhodochrous	107, 147, 626, 628
236.	Mycobacterium smegmatis	422, 485, 508, 1014, 1182, 1183
237.	Mycobacterium stercoris	1014

		Rx. Nos.
238.	Mycobacterium strains	154
239.	Mycoderma aceti (same as Acetobacter aceti)	310, 427
240.	Neisseria winogradskyi	338
241.	Neurospora crassa	474, 994
242.	Neurospora mutants	1038, 1076, 1247, 1248, 1249
243.	Nocardia species	138, 604, 627
244.	Oidium lactis (same as Geotrichum candidum)	680, 980, 1008, 1029, 1031, 1041, 1043, 1047, 1061, 1078, 1093, 1094, 1104
245.	Oidium species	16
246.	Ophiobolus herpotrichus	489, 490, 491, 494, 497, 499, 500, 505, 507
247.	Parasitella simplex	464, 465, 473
248.	Penicillium adametzi	569
249.	Penicillium brevicaule (same as Scopulariopsis brevicaulis)	873, 875, 877, 878, 879, 905, 906, 1207, 1210, 1214, 1216, 1217, 1218, 1219, 1220, 1221, 1222, 1224, 1225, 1226, 1227, 1228, 1229, 1234, 1235, 1238
250.	Penicillium brevi-compactum	1118
251.	Penicillium charlesii	1112
252.	Penicillium chrysogenum	151, 244, 325, 515, 532, 566, 568, 622, 766, 1016, 1020, 1126, 1158, 1175, 1208, 1211, 1223, 1234
253.	Penicillium citrinum	318, 552, 553, 578, 579, 580, 581, 582, 583
254.	Penicillium corylophilum	196
255.	Penicillium crustaceum	51, 326
256.	Penicillium crostosum	335
257.	Penicillium decumbens	578, 579, 581, 583

		Rx. Nos.
258.	Penicillium digitatum	927, 928, 1109, 1251, 1296
259.	Penicillium expansum	1106
260.	Penicillium glaucum	526, 528, 530, 533, 535, 536, 537, 591, 592, 593, 594, 929, 937, 938, 940, 942, 944, 946, 947, 948, 949, 950, 1103, 1184
261.	Penicillium griseo-fulvum	621, 1265
262.	Penicillium lilacinum	196, 546, 554, 783
263.	Penicillium luteum	322, 1108, 1114, 1115, 1116, 1117
264.	Penicillium luteum-purpurogenum (Nomen dubium)	51, 299, 304, 317, 318, 322
265.	Penicillium notatum	515, 578, 579, 581, 583, 884, 887, 1208, 1211, 1223, 1234
266.	Penicillium olivaceum	320
267.	Penicillium purpurogenum	322
268.	Penicillium sclerotiorum	1113
269.	Penicillium species	110, 160, 161, 172, 173, 211, 317, 552, 553, 556, 557, 580, 582, 1019, 1080, 1232, 1233
270.	Penicillium tardum	196
271.	Penicillium urticae	208
272.	Pestalotia foedans	195
273.	Pestalotia funera	171
274.	Pestalotia royenae	195
275.	Peziza species	237
276.	Phycomyces blakesleeanus	126, 188, 210
277.	Phytomonas betae-gelatae	1134
278.	Phytomonas species	332, 1180
279.	Phytomonas tumefaciens (same as Agrobacterium tumefaciens)	1132

		Rx. Nos.
280.	Pichia farinosa	1035, 1062, 1081
281.	Proactinomyces erythropolis (same as Mycobacterium rhodochrous)	107, 147, 626, 628
282.	Proactinomyces roseus	149, 286
283.	Proactinomyces species	113, 627
284.	Propionibacterium arabinosum	856
285.	Propionibacterium pentosaceum	932
286.	Protaminobacter alboflavum	362, 363, 366, 372, 385, 387, 392, 393, 394, 401, 409, 412, 416, 417, 418, 419, 421
287.	Protaminobacter rubrum	362, 363, 366, 372, 385, 387, 392, 393, 394, 401, 409, 412, 416, 417, 418, 419, 421
288.	Proteus species	1049, 1050
289.	Proteus vulgaris	98, 847, 956, 966, 1024, 1033, 1036, 1045, 1057, 1088, 1098, 1198
290.	Pseudodiphtheria bacilli	112, 121
291.	Pseudomonas aeruginosa	80, 83, 88, 287, 455, 606, 607, 608, 1015, 1186, 1203
292.	Pseudomonas alginoliquefaciens (Alginomonas specie?)	1171
293.	Pseudomonas aromatica	1272
294.	Pseudomonas aureofaciens	1145
295.	Pseudomonas beijerinckii	39
296.	Pseudomonas boreopolis	607
297.	Pseudomonas calco-acetica	1262
298.	Pseudomonas chlororaphis	1145, 1310
299.	Pseudomonas desmolyticum	604, 605
300.	Pseudomonas eisenbergii	1262
301.	Pseudomonas fluorescens	60, 62, 73, 77, 79, 87, 89, 342, 351, 509, 791, 807, 958, 1145, 1270

		Rx. Nos.
302.	Pseudomonas fragi	293
303.	Pseudomonas gluconicum	336, 357
304.	Pseudomonas graveolens	293, 356, 359
305.	Pseudomonas lindneri (same as Zymomonas mobilis)	880, 882, 904
306.	Pseudomonas mildenbergii	61, 85, 301, 341
307.	Pseudomonas mors-prunorum	1142
308.	Pseudomonas mucidolens	332
309.	Pseudomonas oryzae	437
310.	Pseudomonas ovalis	332, 1301
311.	Pseudomonas prunicola (same as Pseudomonas syringae)	1142
312.	Pseudomonas putida	331
313.	Pseudomonas savastanoi	313
314.	Pseudomonas species	90, 294, 297, 301, 341, 356, 357, 359, 518, 519, 604, 620, 623, 624, 1142, 1180
315.	Pseudomonas synxantha	293
316.	Pseudomonas syringae	1142
317.	Pseudomonas vendrelli	293, 297
318.	Pseudomonas woodsii	357
319.	Pycnodothis species	128, 373, 551
320.	Pycnosporium species	276
321.	Rhizobium trifolii	953
322.	Rhizoctonia ferrugena	258, 260
323.	Rhizopus arrhizus	162, 164, 182, 189, 190, 214, 215, 219, 227, 233, 254, 262, 263, 540, 782
324.	Rhizopus cambodjae	184

		Rx. Nos.
325.	Rhizopus nigricans	157, 159, 164, 167, 174, 175, 176, 177, 183, 191, 201, 216, 218, 220, 221, 224, 226, 239, 253, 254, 263, 264, 270, 284, 400, 407, 415, 458, 601, 781, 823, 827, 828
326.	Rhizopus reflexus	156, 158, 166, 168, 538, 539, 814, 821
327.	Rhizopus species	162, 166, 192, 255, 1080
328.	Rhodopseudomonas gelatinosa	3
329.	Rhodoseptoria species	277, 600
330.	Saccharomyces cerevisiae	631, 921, 975, 996, 1239
331.	Saccharomyces cerevisiae var. ellipsoideus	974, 1022
332.	Saccharomyces ellipsoideus (same as Saccharomyces cerevisiae)	975, 1023
333.	Saccharomyces logos	1035, 1062, 1081
334.	Saccharomyces pastorianus	244
335.	Saccharomyces rouxii	1110
336.	Saccharomyces species	1075
337.	Salmonella paratyphi	659
338.	Salmonella species	964, 1097
339.	Salmonella typhosa	1096, 1097
340.	Schizomycetes	851, 1260
341.	Schizophyllum commune	1212
342.	Schizosaccharomyces pombe	1035, 1062, 1081, 1121, 1122, 1123
343.	Sclerotinia fructicola	494, 499
344.	Scopulariopsis brevicaulis	873, 875, 876, 877, 878, 879, 885, 886, 902, 903, 905, 906, 920, 1207, 1209, 1210, 1214, 1215, 1216, 1217, 1218, 1219, 1220, 1221, 1222, 1223, 1224, 1225, 1226, 1227, 1228, 1229, 1230, 1231, 1232, 1233, 1234, 1235, 1236, 1237, 1238

		Rx. Nos.
345.	Serratia marcescens	62, 77, 342, 437, 1009, 1304
346.	Serratia species	90
347.	Sorbose bacterium (Acetobacter xylinum)	307
348.	Spicaria species	282
349.	Spirochaeta cytophaga (same as Sporocytophaga myxococcoides	456, 1170
350.	Sporocytophaga myxococcoides	456, 1169, 1170
351.	Staphylococcus aureus	1196, 1202, 1304
352.	Staphylococcus candicans	965
353.	Staphylococcus pyogenes aureus (same as Staphylococcus aureus)	1304
354.	Sterigmatocystis nigra (same as Aspergillus niger)	314
355.	Streptobacterium casei (same as Lactobacillus casei)	1066
356.	Streptococcus bovis	969, 1151
357.	Streptococcus equinus	925
358.	Streptococcus faecalis	447, 925
359.	Streptococcus hornensis	1147
360.	Streptococcus inulinaceous (possibly Streptococcus bovis)	969
361.	Streptococcus lactis	969
362.	Streptococcus pyogenes	1127
363.	Streptococcus salivarius	1140
364.	Streptococcus species	969, 1147, 1152, 1153
365.	Streptococcus varians	18, 26, 27, 28
366.	Streptomyces albidoflavus	59

		Rx. Nos.
367.	Streptomyces aureofaciens	180, 461
368.	Streptomyces coelicolor	726
369.	Streptomyces fradiae	234, 243, 272
370.	Streptomyces flaveolus	59
371.	Streptomyces gelaticus	141, 142, 143, 145, 586, 587, 589
372.	Streptomyces lavendulae	375, 376, 386, 544, 577, 584, 715, 716, 717, 1307
373.	Streptomyces roseochromogenus	165, 170, 251
374.	Streptomyces species	59, 114, 126, 129, 213, 244, 250, 259
375.	Torula species	1075
376.	Trichoderma lignorum	469
377.	Trichoderma species	469
378.	Trichoderma viride	467
379.	Trichothecium roseum	130, 247, 278, 477, 484
380.	Ustulina deusta	453
381.	Ustulina vulgaris (same as Ustulina deusta)	453
382.	Vibrio cuneata	617, 618, 619
383.	Willia anomala (same as Hansenula anomala)	1090, 1094, 1103, 1104, 1253
384.	Willia anomala var. saké (probably Hansenula anomala)	558, 561, 564
385.	Willia species	1075
386.	Wojnowicia graminis	493
387.	Xanthomonas oryzae	437
388.	Xanthomonas uredovorus	66, 346

	Rx. Nos.
389. **Yeasts**	103, 105, 115, 288, 290, 353, 354, 430, 558, 561, 563, 564, 602, 625, 630, 632, 633, 634, 637, 638, 639, 641, 644, 645, 646, 647, 648, 650, 651, 652, 653, 654, 655, 656, 657, 658, 662, 663, 664, 665, 666, 667, 668, 669, 670, 675, 676, 677, 678, 679, 681, 682, 683, 684, 686, 687, 688, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 703, 704, 709, 710, 718, 719, 720, 721, 722, 723, 724, 731, 733, 737, 738, 740, 741, 742, 744, 745, 746, 747, 748, 749, 750, 751, 753, 756, 757, 758, 759, 760, 761, 762, 763, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 784, 785, 790, 792, 793, 794, 795, 796, 797, 798, 799, 801, 802, 803, 804, 805, 806, 808, 809, 811, 812, 813, 822, 832, 833, 834, 835, 857, 860, 864, 865, 867, 868, 869, 870, 871, 872, 874, 881, 883, 907, 910, 912, 913, 914, 915, 916, 917, 918, 919, 924, 926, 973, 976, 977, 979, 981, 982, 985, 989, 992, 995, 997, 998, 999, 1000, 1002, 1003, 1004, 1005, 1006, 1011, 1012, 1021, 1027, 1028, 1030, 1039, 1042, 1048, 1055, 1075, 1077, 1080, 1083, 1084, 1091, 1092, 1095, 1101, 1173, 1181, 1188, 1205, 1206, 1239, 1241, 1242, 1243, 1244, 1246, 1250, 1255, 1257, 1259, 1287, 1288, 1289, 1290, 1291, 1292, 1293, 1294, 1295, 1303
390. **Zymomonas mobilis**	880, 882, 904

AUTHOR INDEX

	Author	Rx. Nos.
1.	Abe, T.	1304
2.	Ackermann, D.	908, 952, 960, 961, 1059, 1192, 1193, 1194, 1199
3.	Acklin, O.	949
4.	Agnello, E. J., B. M. Bloom and G. D. Laubach	280, 481
5.	Akamatsu, S.	667
6.	Albericci, V. J., T. P. Curtin and D. Reilly	1113
7.	Alsberg, C. L.	313
8.	Amatsu, H. and M. Tsudji	966, 1032, 1033
9.	Amelung, H.	316
10.	Ames, B. N. and H. K. Mitchell	1038, 1076, 1247, 1248, 1249
11.	Angeletti, A.	51, 326
12.	Angeletti, A. and C. F. Cerruti	304, 322
13.	Angeletti, A. and C. F. Cerutti	299
14.	Antoniani, C. and R. M. Cioffi	975, 1023
15.	Arai, M.	956, 1024, 1025
16.	Arnaudi, C.	104
17.	Arnaudi, C. and C. Colla	150
18.	Asai, T., K. Aida and Y. Ueno	73, 351
19.	Aubel, E. and F. Egami	1069

	Author	Rx. Nos.
20.	Baba, S.	613, 1240
21.	Baba, T.	1244
22.	Babička, J., J. Volf and J. Lebeda	927, 928, 1296
23.	Bailey, R. W. *et al.*	1129, 1156, 1157
24.	Banning, F.	441
25.	Barker, H. A.	435, 449
26.	Barker, S. A., E. J. Bourne and M. Stacey	1136
27.	Barker, S. A. *et al.*	1124, 1130, 1152
28.	Barnett, J. A. and T. Swain	1188
29.	Bauer, E.	1146
30.	Baumann, E.	1063
31.	Baumgärtel, T. and D. Zahn	830, 862
32.	Behrens, M. and N. N. Ivanov	1290, 1291
33.	Beijerinck, M. W.	1262, 1272
34.	Bernhauer, K.	860
35.	Bernhauer, K. and K. Schön	12, 69
36.	Bernhauer, K. and K. Irrgang	565
37.	Bernhauer, K. and B. Görlich	54, 75, 621, 1265
38.	Bernhauer, K. and H. Knobloch	76, 82
39.	Bernhauer, K. and E. Riedl-Tůmová	295, 302
40.	Bernstein, S. *et al.*	281, 282
41.	Berthelot, A. and D. M. Bertrand	962, 967

	Author	Rx. Nos.
42.	Bertrand, G.	9, 23, 53, 81, 94, 96, 291, 298, 307
43.	Bertrand, G. and G. Nitzberg	91
44.	Billen, D. and H. C. Lichstein	953
45.	Binder-Kotrba, G.	1001, 1278
46.	Bird, M. L. and F. Challenger	1208, 1211, 1232, 1233, 1234
47.	Bird, M. L. *et al.*	920, 1223, 1237
48.	Birkinshaw, J. H. *et al.*	765
49.	Birkinshaw, J. H. and H. Raistrick	325, 766, 1109
50.	Birkinshaw, J. H., J. H. V. Charles and H. Raistrick	1109, 1251
51.	Blackburn, S. and F. Challenger	873, 878, 879, 1217, 1218
52.	Blackwood, A. C. and E. R. Blakley	66, 346, 661
53.	Blanchard, K. C. and J. MacDonald	743, 899
54.	Bloom, B. M. and G. M. Shull	596, 598
55.	Boas, F.	1187
56.	Bodánszky, A., J. Kollonitsch and G. Wix	547, 570
57.	Boekhout, F. W. J.	1147
58.	Bokorny, T.	1205, 1206
59.	Bolcato, V. and G. Pasquini	659
60.	Bopp, F.	1086
61.	Bousfield, E. G., G. G. H. Wright and T. K. Walker	13

	Author	Rx. Nos.
62.	Boutroux, L.	67, 310, 347
63.	Bovarnick, M.	1309
64.	Braak, H. R.	853
65.	Bracken, A.	1096
66.	Brasch, W.	888, 889, 1051, 1052, 1053, 1056, 1064
67.	Braunstein, A. E. and M. M. Lewitow	1259
68.	Brown, A. J.	48, 49, 311, 439, 443, 1105
69.	Brunel-Capelle, G.	996
70.	Bruyn, J.	616
71.	Butenandt, A. and H. Dannenberg	542, 694
72.	Butenandt, A., H. Dannenberg and L. Surányi	693, 695, 808, 809
73.	Butenandt, A. and L. Surányi	710
74.	Butkewitsch, W.	1017, 1263, 1264
75.	Butkewitsch, W. and M. W. Fedoroff	601
76.	Butlin, K. R.	330
77.	Butlin, K. R. and W. H. D. Wince	7
78.	Byrde, R. J. W., J. F. Harris and D. Woodcock	521, 522, 523, 524
79.	Byrde, R. J. W. and D. Woodcock	511, 512, 513, 514, 516, 517
80.	Calmette, A.	1185
81.	Camerino, B., C. G. Alberti and A. Vercellone	187, 720, 721, 722
82.	Camerino, B. et al.	184

	Author	Rx. Nos.
83.	Camerino, B. and A. Vercellone	718, 719, 723, 724
84.	Čapek, A. et al.	552, 553, 571, 580, 582
85.	Carruthers, A. and E. A. Cooper	1133, 1149
86.	Castell, C. H. and E. H. Garrard	1180
87.	Challenger, F.	906, 1236
88.	Challenger, F., V. Subramaniam and T. K. Walker	340, 452, 487, 610, 611
89.	Challenger, F. and L. Klein	615
90.	Challenger, F., C. Higgenbottom and L. Ellis	1219, 1220, 1224, 1235
91.	Challenger, F. and H. E. North	905, 1207, 1210
92.	Challenger, F. and L. Ellis	1221, 1222, 1225
93.	Challenger, F. and C. Higginbottom	1238
94.	Challenger, F. and A. A. Rawlings	875, 877, 1214, 1216, 1226, 1227, 1228, 1229
95.	Challenger, F. and P. T. Charlton	886, 1212, 1231
96.	Challenger, F. and D. Greenwood	876, 1215
97.	Challenger, F. and Y. Cheng Liu	884, 885, 887, 902, 903
98.	Challenger, F., D. B. Lisle and P. B. Dransfield	1209, 1230
99.	Chen, S. L. and H. J. Peppler	921
100.	Chikano, M. and T. Kitano	1008, 1078
101.	Chrzaczcz, T. and M. Zakomorny	1200

	Author	Rx. Nos.
102.	Clutterbuck, P. W. et al.	1112
103.	Coleman, D. L. and C. A. Baumann	829, 831
104.	Colingsworth, D. R., M. P. Brunner and W. J. Haines	243, 272
105.	Cook, R. P. and B Woolf	1057
106.	Cooper, E. A. and J. F. Preston	1133
107.	Coppock, P. D., V. Subramaniam and T. K. Walker	155, 930, 936
108.	Cosbie, A. J. C., J. Tošic and T. K. Walker	436
109.	Coyne, F. P. and H. Raistrick	764
110.	Cozic, M.	92
111.	Crowe, B. F.	1286
112.	Crowley, N. and M. P. Jevons	1127
113.	Daker, W. D. and M. Stacey	1150
114.	Dakin, H. D.	354, 670, 773
115.	Delaporte, B. and H. Belval	1134
116.	De Ley, J.	1245
117.	Delwiche, E. A.	932
118.	Desnuelle, P. and L. Grand	890, 901, 1070, 1071, 1072
119.	Dodson, R. M., A. H. Goldkamp and R. D. Muir	110, 160, 161, 172, 173
120.	Dox, A. W.	1107
121.	Dox, A. W. and R. E. Neidig	1106, 1131
122.	Dransfield, P. B. and F. Challenger	1213

	Author	Rx. Nos.
123.	Duff, R. B., D. M. Webley and V. C. Farmer	1308
124.	Dulaney, E. L. et al.	186, 196, 197, 203, 211, 229, 241, 268, 463
125.	Dulaney, E. L., E. O. Stapley and C. Hlavac	185, 198, 240, 269
126.	Egami, F.	1100
127.	Eguchi, T.	144, 588
128.	Ehrlich, F.	973, 976, 977, 978, 979, 981, 982, 985, 1006, 1021, 1027, 1028, 1030, 1039, 1048, 1055, 1084, 1091, 1092, 1104
129.	Ehrlich, F. and K. A. Jacobsen	1031, 1043, 1047
130.	Ehrlich, F. and P. Pistschimuka	1090, 1094
131.	Ehrlich, F. and F. Lange	1103
132.	Ellinger, A.	954, 957
133.	Emmerling, O. and O. Reiser	1270
134.	Emmerling, O. and E. Abderhalden	1261
135.	Eppstein, S. H. et al.	162, 166, 168, 174, 175, 239, 539, 821
136.	Ercoli, A.	111, 116, 117, 123, 125, 146
137.	Ercoli, A. and L. Molina	118
138.	Ercoli, A. and P. De Ruggieri	731
139.	Ercoli, A. and P. De Ruggieri and D. Della Morte	221
140.	Erikson, D.	1142
141.	Evans, W. C.	617, 618, 619

	Author	Rx. Nos.
142.	Ewins, A. J. and P. P. Laidlaw	971
143.	Fairhurst, A. S., H. K. King and C. E. Sewell	1298
144.	Falck, R. and S. N. Kapur	315
145.	Färber, E., F. F. Nord and C. Neuberg	630
146.	Färber, G.	78, 86
147.	Farkas, L. and B. Schneidmesser	789
148.	Feingold, D. S.	1144
149.	Fenaroli, P.	763
150.	Fischer, F. G., O. Wiedemann and W. Robertson	657, 658, 663, 668, 675, 681, 682, 683, 792, 793, 796, 797, 802, 803, 805, 806, 811, 812, 813
151.	Fischer, F. G. and O. Wiedemann	746, 761, 762, 768, 775, 784, 785, 790, 794, 795, 798, 799, 801, 804, 910, 924, 926, 1003, 1005
152.	Fischer, F. G. and W. Robertson	786, 800
153.	Foda, I. O. and R. H. Vaughn	99, 360
154.	Foster, J. W.	18, 26, 27, 28
155.	Franke, W. and G. E. Hahn	1203
156.	Freeman, G. G. and C. S. Macpherson	1114, 1115, 1116, 1117
157.	Freund, A.	851
158.	Fried, J., R. W. Thoma and A. Klingsberg	368, 375, 376, 382, 397, 544, 568, 577, 715
159.	Fried, J. et al.	163, 165, 170, 180, 181, 188, 193, 207, 210, 222, 223, 228, 232, 238, 251, 266, 267, 274, 386, 461, 466, 584, 716, 717
160.	Friedmann, E.	648

	Author	Rx. Nos.
161.	Fuchs, A.	1145
162.	Fujise, S.	353, 651
163.	Fukui, T.	735
164.	Fulmer, E. I. and L. A. Underkofler	25, 56
165.	Fulmer, E. I., J. W. Dunning and L. A. Underkofler	52
166.	Fulmer, E. I. *et al.*	55
167.	Gale, G. R.	1014
168.	Gilvert, von and V. Subramanian	431
169.	Giri, K. V. *et al.*	1126
170.	Gladkova, V. N., S. R. Mardashev and L. A. Semina	965
171.	Godin, P.	1118
172.	Goepfert, G. J.	8, 17, 559, 562
173.	Goepfert, G. J. and F. F. Nord	19, 24, 560
174.	Gorin, P. A. J. and A. S. Perlin	1110
175.	Gottlieb, D., P. W. Robbins and H. E. Carter	1307
176.	Gould, D. *et al.*	729
177.	Gray, B. E.	84, 85
178.	Gray, W. D.	1252
179.	Greenspan, G. *et al.*	258, 260
180.	Grimmer, W. and B. Wauschkuhn	970, 984, 1041, 1066, 1089
181.	Grivsky, E.	20, 21
182.	Grossman, J. P. and J. R. Postgate	859

	Author	Rx. Nos.
183.	Grzycki, S.	646, 748
184.	Gunsalus, I. C.	447
185.	Hahn, A. and W. Lintzel	1101
186.	Haines, W. J. and D. R. Colingsworth	244
187.	Halperin, A. H., J. H. Quastel and P. G. Scholefield	138
188.	Hammer, B. W. et al.	640, 642
189.	Hanaoka, A., T. Harada and T. Takizawa	442, 451, 614
190.	Hanč, O. et al.	578, 579, 581, 583
191.	Hann, R. M., E. B. Tilden and C. S. Hudson	31, 93, 95
192.	Harden, A.	1054
193.	Harrison, F. C., H. L. A. Tarr and H. Hibbert	1139, 1160
194.	Haworth, W. N., H. Raistrick and M. Stacey	1112
195.	Hayakawa, S.	139, 585
196.	Hayakawa, S., Y. Saburi and I. Akaeda	145, 589
197.	Hayakawa, S., Y. Saburi and H. Teraoka	140, 142, 143, 586
198.	Hayakawa, S. et al.	141, 587
199.	Hayano, M. et al.	468
200.	Hayasida, A.	300
201.	Hehre, E. J.	1153, 1161
202.	Heitzmann, P.	649

	Author	Rx. Nos.
203.	Henry, T. A. and S. J. M. Auld	1173
204.	Hermann, S. and P. Neuschul	292, 305, 308, 324
205.	Herrick, H. T. and O. E. May	318
206.	Herzog, H. L. *et al.*	259
207.	Herzog, R. O. and O. Ripke	1018
208.	Hestrin, S., S. Avineri-Shapiro and M. Aschner	1141
209.	Hida, T.	1111
210.	Hirai, K.	959, 983, 1036, 1040, 1088, 1098
211.	Hockenhull, D. J. D. *et al.*	532, 566, 622, 1016, 1020
212.	Hoehn, W. M., L. H. Schmidt and H. B. Hughes	136, 137
213.	Hoffman, C. E. and J. O. Lampen	1204
214.	Hopkins, F. G. and S. W. Cole	1068
215.	Hori, I. and T. Nakatani	87, 89
216.	Horsters, H.	980, 1029, 1093
217.	Horváth, J. and A. Krámli	148, 590
218.	Hughes, D. E.	509
219.	Hughes, H. B. and L. H. Schmidt	108, 133, 134
220.	Humphreys, F. B.	1268
221.	Ichihara, K. *et al.*	922, 923
222.	Ikeda, Y.	62, 77, 336, 342, 437, 567
223.	Imshenetskiĭ, A. A. and L. A. Kuzyurina	58
224.	Ishikawa, I.	1253

	Author	Rx. Nos.
225.	Iwata, H.	1168
226.	Iwatsuru, R.	991
227.	Jackson, A. W. and A. E. Pasieka	1196, 1202
228.	Jaminet, F.	1019
229.	Jephcott, C. M. and R. Robison	1243
230.	Kahnt, F. W. et al.	255
231.	Karabinos, J. V. and H. J. Ferlin	527, 529, 531, 534, 939, 941, 943, 945
232.	Karrer, P.	537
233.	Katagiri, E. and K. Kitahara	660
234.	Katagiri, H. and K. Itagaki	337
235.	Katz, J., I. Lieberman and H. A. Barker	1305, 1306
236.	Katznelson, H. and S. W. Tanenbaum	100, 361
237.	Katznelson, H., S. W. Tanenbaum and E. L. Tatum	72, 350
238.	Kayser, E.	1250
239.	Kepner, R. E., J. G. B. Castor and A. D. Webb	974, 1022
240.	Kihara, H., J. M. Prescott and E. E. Snell	925
241.	Kim, C. H.	733, 737, 1255, 1257
242.	Kirch, E. R.	1190
243.	Kistner, A.	609
244.	Kiyokawa, M.	1061
245.	Kling, A.	4, 5

	Author	Rx. Nos.
246.	Klüger, B., R. Siebert and A. Schubert	209
247.	Kluyver, A. J. and F. J. G. de Leeuw	68, 348
248.	Kluyver, A. J., T. Hof and A. G. J. Boezaardt	39
249.	Kluyver, A. J. and C. G. T. P. Schnellen	892, 894, 898
250.	Kluyver, A. J., J. de Ley and A. Rijven	356, 359
251.	Kluyver, A. J. and J. C. M. van Zijp	510
252.	Koessler, K. and M. T. Hanke	963
253.	Koessler, K., M. T. Hanke and M. S. Sheppard	964, 969
254.	Koester, H., L. Mamoli and A. Vercellone	105, 704
255.	Kögl, F., B. Tönnis and H. J. Groenewegen	1310
256.	Kooi, E. R.	1162
257.	Kotake, Y., M. Chikano and K. Ichihara	680
258.	Kraght, A. J. and M. P. Starr	1178
259.	Krámli, A. and J. Horváth	149, 286
260.	Krehan, M.	433
261.	Kuhn, R. and F. Ebel	1011
262.	Kulhánek, M.	80, 83, 88
263.	Kulka, D., A. N. Hall and T. K. Walker	63, 71, 343
264.	Kulka, D. and T. K. Walker	65, 345

	Author	Rx. Nos.
265.	Kützing, F.	426
266.	Laidlaw, P. P.	972
267.	Langlykke, A. F. and E. B. Fred	629, 643, 739
268.	Lassota, Z. et al.	154
269.	Leaver, F. W., H. G. Wood and R. Stjernholm	856
270.	Le Bel, J. A.	446
271.	Lemoigne, M.	1271
272.	Lemoigne, M. and M. Croson	338
273.	Leopold, H.	1095
274.	Levene, P. A. and A. Walti	631, 644, 662, 756, 760
275.	Liebig, J.	857
276.	Liebster, J., M. Kulhánek and M. Tadra	32
277.	Lindner, F. et al.	400, 407, 415
278.	Linneweh, F.	1102, 1197
279.	Lintner, C. J. and H. J. V. Liebig	758, 907, 1295
280.	Lintner, C. J. and H. Lüers	741
281.	Lockwood, L. B., B. Tabenkin and G. E. Ward	61, 332, 341
282.	Lockwood, L. B. and G. E. N. Nelson	293, 294, 297, 301
283.	Loew, O.	1260
284.	Loicjanskaya, M. S.	456, I170
285.	Loitsyanskaya, M. S.	14, 57, 339
286.	Lüers, H. and Mengele, J.	864, 867, 868, 869, 870, 871, 872, 915, 918

	Author	Rx. Nos.
287.	Lwoff, A. and H. Ionesco	935
288.	McAleer, W. J. and E. L. Dulaney	467, 493
289.	McIntire, F. C., W. H. Peterson and A. J. Riker	1132
290.	Maassen, A.	1254
291.	Machida, M.	734, 736
292.	Magasanik, B. and E. Chargaff	38, 42, 43
293.	Mamoli, L.	103, 115, 122, 124, 132, 692, 701, 703, 709, 738, 822, 1181
294.	Mamoli, L. and A. Vercellone	102, 696, 697, 698, 700
295.	Mamoli, L. and G. Schramm	705, 706, 810
296.	Mamoli, L., R. Koch and H. Teschen	702, 707, 711, 712, 713, 714 815, 816, 817, 819, 820, 825
297.	Mancera, O. et al.	192
298.	Mann, K. M., F. R. Hanson and P. W. O'Connell	246, 476
299.	Masuo, E. and E. Kondo	59
300.	Masuo, E. and Y. Nozaki	64, 74, 296, 303, 306, 309, 344, 352
301.	Masuo, E., F. Shima and K. Yoshida	357
302.	Masuo, E. et al.	90
303.	Mathieson, Olin Chemical Corp.	247, 278
304.	May, A.	913
305.	May, O. E. et al.	317
306.	Mayer, P.	671, 672, 770
307.	Mayer, P. and C. Neuberg	778

	Author	Rx. Nos.
308.	Mazé, P. and M. Ruot	15, 16
309.	Meister, P. D.	473
310.	Meister, P. D. et al.	131, 202, 225, 236, 242, 254, 256, 459, 462, 464, 471, 475, 478, 482, 483, 782
311.	Merck and Co., Inc.	469
312.	Meystre, C., E. Vischer and A. Wettstein	130, 235, 237, 248, 249, 477, 484, 491, 497, 505
313.	Mezzadroli, G. and A. Marsigli	689
314.	Mickelson, M. N. and C. H. Werkman	855
315.	Minor, F. W. et al.	1125
316.	Mitoma, C.,H. Weissbach and S. Udenfriend	520
317.	Miyaji, K.	1007, 1026, 1034, 1037, 1046, 1065, 1085, 1099
318.	Molina, L. and A. Ercoli	106, 119, 120
319.	Molinari, E.	1275, 1280, 1281, 1282, 1283, 1284, 1285
320.	Molliard, M.	314
321.	Morooka, N.	1155
322.	Mosel, H.	434
323.	Müller, D.	2
324.	Murphy, D.	1143
325.	Murphy, D., C. T. Bishop and G. A. Adams	1110
326.	Murphy, J. F. and R. W. Stone	620

	Author	Rx. Nos.
327.	Murray, H. C. and D. H. Peterson	156, 158, 164, 167, 176, 177, 178, 189, 191, 194, 214, 215, 216, 217, 218, 219, 220, 224, 226, 227, 233, 234, 253, 261, 262, 264, 265, 270, 271, 284, 285, 457, 460, 465, 479, 480, 486, 538, 540, 541, 781, 814, 823, 824, 828
328.	Nagelschmidt, G.	639
329.	Nencki, M.	1067
330.	Neubauer, O. and K. Fromherz	676, 679, 1004, 1077
331.	Neuberg, C.	652, 684, 757, 904, 909, 934, 986, 988, 1060, 1087
332.	Neuberg, C. and L. Karczag	1058
333.	Neuberg, C. and J. Kerb	647, 745, 747, 751, 779, 995, 997
334.	Neuberg, C. and H. Steenbock	750
335.	Neuberg, C. and E. Welde	769, 772, 832, 833, 834, 914, 916, 917
336.	Neuberg, C. and F. F. Nord	637, 638, 653, 665, 666, 669, 688, 759, 912
337.	Neuberg, C. and W. H. Peterson	992, 999, 1002
338.	Neuberg, C. and E. Schwenk	740, 874, 1012
339.	Neuberg, C. and M. Ringer	290, 753, 989, 990
340.	Neuberg, C. and A. Lewite	664
341.	Neuberg, C. and E. Reinfurth	835, 919, 1287
342.	Neuberg, C. and J. Hirsch	1288
343.	Neuberg, C. and B. Arinstein	1013
344.	Neuberg, C. and L. Liebermann	1292, 1293
345.	Neuberg, C. and A. von May	1294

	Author	Rx. Nos.
346.	Neuberg, C. and B. Rewald	993
347.	Neuberg, C. and G. Gorr	650
348.	Neuberg, C. and M. Kobel	641
349.	Neuberg, C. and F. Windisch	1274, 1276, 1277
350.	Neuberg, C. and E. Simon	636, 673, 674, 752, 754, 755, 865, 866, 1279
351.	Neuberg, C. and W. Komarewsky	677
352.	Neuberg, C. and A. Vercellone	744
353.	Neuberg, C. and W. M. Cahill	656
354.	Neuberg, C. and H. Lustig	1246
355.	Neuberg, C. and A. Grauer	880, 882
356.	Neuberg, C., H. Lustig and R. N. Cagan	686, 687
357.	Nishikawa, M., S. Noguchi and T. Hasegawa	377, 381
358.	Nishikawa, M. et al.	383
359.	Niven, C. F., K. L. Smiley and J. M. Sherman	1140, 1151
360.	Nord, F. F.	771, 881, 883, 951
361.	Noyes, A. A. and W. H. Watkins	852
362.	Ohta, K.	767
363.	Osburn, O. L., R. W. Brown and C. H. Werkman	900
364.	Otsuka, S. et al.	1301
365.	Pakes, W. C. C. and W. H. Jollyman	1009
366.	Paretsky, D.	1297

	Author	Rx. Nos.
367.	Pasteur, L.	427
368.	Pauly, H. and K. Feuerstein	776, 777, 780
369.	Pederson, R. L. et al.	157, 159, 458
370.	Peel, J. L. and H. A. Barker	787
371.	Perlman, D.	126
372.	Perlman, D., E. Titus and J. Fried	212, 826
373.	Perlman, D. et al.	129, 213
374.	Pervozvanskiĭ, V. V. and M. A. Ivashkevich	331
375.	Peterson, D. H.	101, 169, 208, 783
376.	Peterson, D. H. and H. C. Murray	190
377.	Peterson, D. H. et al.	179, 182, 183, 201, 263, 546, 549, 554, 556, 557, 569, 575, 827
378.	Peterson, G. E. et al.	573
379.	Peterson, W. H. and M. J. Johnson	931, 987
380.	Peterson, W. H., S. W. Scott and W. S. Thompson	1166, 1167
381.	Pfizer, C. and Co., Inc.	199
382.	Pigulewskii, G. and N. Charik	595, 1179
383.	Podolsky, R. J.	1191
384.	Porges, N., T. F. Clark and E. A. Gastrock	333
385.	Posternak, T.	36, 37, 40, 41
386.	Posternak, T. and F. Ravenna	34

	Author	Rx. Nos.
387.	Posternak, T. and D. Reymond	35
388.	Posternak, T., D. Reymond and H. Friedli	33
389.	Potter, L. F. and E. McCoy	1172
390.	Prelog, V. and W. Acklin	685
391.	Quastel, J. H. and B. Woolf	1302
392.	Raistrick, H.	1097
393.	Raistrick, H. and M. L. Rintoul	1108
394.	Reichstein, T.	30
395.	Richtmyer, N. K., L. C. Stewart and C. S. Hudson	46
396.	Robbins, W. J. and E. C. Lathrop	355
397.	Robison, R. and W. T. J. Morgan	1241, 1242
398.	Rogoff, M. H. and I. Wender	607, 608
399.	Rona, E.	774
400.	Rosenfeld, L.	749
401.	Rothrock, J. W., T. H. Stoudt and J. D. Garber	151, 1175, 1176
402.	Rubin, B. A. et al.	206, 496
403.	Russi, S. and A. Ballio	1158
404.	Sakaguchi, K.	327
405.	Sakaguchi, K., I. Asai and Y. Ikeda	334
406.	Sakaguti, K. and S. Tada	788, 858, 861
407.	Salkowski, E.	1189
408.	Santomauro, P.	645

	Author	Rx. Nos.
409.	Sasaki, T.	968
410.	Sasaki, T. and I. Otsuka	1049
411.	Sasaki, T. and J. Kinose	1050
412.	Sazerac, R.	429
413.	Schardinger, F.	1164, 1165
414.	Schering Corp.	406, 414
415.	Schiesser, A.	1177
416.	Schmidt, G. C., M. A. Logan and A. A. Tytell	1195, 1201
417.	Schmidt, L. H. et al.	135
418.	Schönbrunner, J.	791, 807
419.	Schramm, G. and L. Mamoli	708, 818
420.	Seifert, W.	50, 312, 428, 440, 444, 448, 450
421.	Sen, H. K.	632, 633, 998, 1000
422.	Sen, H. K. and C. Barat	634
423.	Serjak, W. C. et al.	1269
424.	Shah, P. C. et al.	1299, 1300
425.	Shibasaki, K.	1121, 1122, 1123
426.	Shimazu, Y.	625, 678, 1289
427.	Shull, G. M.	128, 257, 275, 276, 277, 283, 362, 363, 366, 372, 373, 385, 387, 391, 392, 393, 394, 401, 409, 412, 416, 417, 418, 419, 421, 551, 574, 576, 597, 599, 725, 727
428.	Shull, G. M., D. A. Kita and J. W. Davisson	231, 245, 273, 279, 470

	Author	Rx. Nos.
429.	Shull, G. M., J. L. Sardinas and J. B. Routien	195
430.	Shull, G. M. and D. A. Kita	205, 230, 422, 485, 1182, 1183
431.	Siegel, J. M. and M. D. Kamen	3
432.	Sihn, T. S.	732
433.	Sijpesteijn, A. K. and S. R. Elsden	933
434.	Simon, E.	289, 432
435.	Sloane, N. H., C. Crane and R. L. Mayer	508
436.	Smith, R. G.	1137, 1138, 1159
437.	Smith, B. S. W., J. D. Jones and W. C. Evans	612
438.	Smith, G. N. and C. S. Worrel	98, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 1198
439.	Sørensen, L. H.	1169
440.	Stadtman, T. C. and H. A. Barker	1010
441.	Stärkle, M.	526, 528, 530, 533, 535, 536, 938, 940, 942, 944, 947, 948
442.	Steiger, M. and T. Reichstein	47
443.	Stent, H. B., V. Subramanian and T. K. Walker	153
444.	Stephenson, M. and L. H. Stickland	891, 893, 895, 896, 897
445.	Stewart, L. C., N. K. Richtmyer, and C. S. Hudson	97, 1273
446.	Stodola, F. H. and L. B. Lockwood	356, 359

	Author	Rx. Nos.
447.	Stodola, F. H., H. J. Koepsell and E. S. Sharpe	1154
448.	Stone, D. et al.	474
449.	Stoudt, T. H. et al.	365, 380, 389, 395, 398, 404, 413, 420
450.	Strawinski, R. J. and R. W. Stone	606
451.	Stubbs, J. J. et al.	60
452.	Sumiki, Y.	319, 320, 1303
453.	Supniewski, J.	287, 455, 1015, 1186
454.	Sutter, D. et al.	402, 403, 728
455.	Syntex, S. A.	506
456.	Szpilfogel, S. A., M. S. De Winter and W. J. Alsche	410, 548, 572, 730
457.	Szulmajster, J., M. Grunberg-Manago and E. Aubel	1239
458.	Tabone, J. and D. Robert	1256, 1258
459.	Tachibana, S.	1163
460.	Takahashi, T. and T. Asai	70, 321, 323, 328, 329, 349, 454, 600
461.	Tarr, H. L. A. and H. Hibbert	1148
462.	Thaler, H. and W. Eisenlohr	591, 592, 593, 594, 929, 937, 946, 950
463.	Thoma, R. W. et al.	171
464.	Tkachenko, E. S.	863
465.	Tosic, J. and T. K. Walker	438

	Author	Rx. Nos.
466.	Treccani, V., N. Walker and C. H. Wiltshire	604
467.	Tsudji, M.	1044, 1045
468.	Turfitt, G. E.	107, 113, 147, 626, 627, 628
469.	Uemura, S.	1035, 1042, 1062, 1075, 1080, 1081, 1083
470.	Uemura, T.	1073, 1074, 1079, 1082
471.	Uhlenhaut, H.	1174
472.	Underkofler, L. A. et al.	22
473.	Utkin, L. M.	335, 515
474.	Van Risseghem, H.	44,45
475.	Van Tieghem, P.	1184
476.	Veibel, S. and E. Bach	654, 655
477.	Vercellone, A. and L. Mamoli	699
478.	Villecourt, P. and H. Blachère	358
479.	Virtanen, A. I. and B. Börlund	11
480.	Virtanen, A. I., K. Karström, and O. Turpeinen	635
481.	Virtanen, A. I. and T. Laine	958
482.	Virtanen, A. I., P. Rintala and T. Laine	955
483.	Vischer, E. and A. Wettstein	109, 127, 364, 367, 374, 384, 388, 543, 550, 555
484.	Vischer, E., C. Meystre and A. Wettstein	369, 370, 371, 378, 379, 390, 396, 399, 405, 423, 424, 425, 545
485.	Vischer, E., J. Schmidlin and A. Wettstein	250, 408, 411, 507, 691
486.	Visser't Hooft, F.	1, 10, 445
487.	Voisenet, E.	288, 1266, 1267

	Author	Rx. Nos.
488.	Wada, E.	518, 519
489.	Wada, E. and K. Yamasaki	623, 624
490.	Walker, N. and G. H. Wiltshire	603, 605
491.	Walker, T. K. and P. D. Coppock	152, 525
492.	Walti, A.	6, 29
493.	Weisz, E., G. Wix and M. Bodánszky	200, 204, 495
494.	Welsch, M. and C. Heusghem	114
495.	Werkman, C. H. and C. F. Gillen	854
496.	Wettstein, A.	252, 472, 690, 726
497.	Wettstein, A., E. Vischer and C. Meystre	490, 494, 499, 500
498.	Wieland, H. and R. Sonderhoff	602
499.	Willson, C. D. and E. A. Adelberg	994
500.	Willstätter, R. and W. Duisberg	742
501.	Wright, H. B. and T. K. Walker	1119, 1120
502.	Wunschendorff, H. and C. Killian	453
503.	Yamada, M.	430, 558, 561, 563, 564
504.	Yamazaki, M.	79
505.	Yaoi, H. and S. Hosoya	911
506.	Yoshikawa, M.	1171
507.	Yuill, J. L.	1135

Author	Rx. Nos.
508. Zaffaroni, A. et al.	488, 489, 492, 498, 501, 502, 503, 504
509. Zilliken, F. et al.	1128
510. Zimmermann, W. and G. May	112, 121

☆ U.S. GOVERNMENT PRINTING OFFICE: 1959 O - 503963